MODERN MACHINE SHOP

CONSTRUCTION, EQUIPMENT AND MANAGEMENT.

PERRIGO

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CONSTRUCTION
EQUIPMENT AND
MANAGEMENT

A COMPREHENSIVE AND PRACTICAL TREATISE ON THE ECONOMICAL BUILDING, THE EFFICIENT EQUIPMENT AND SUCCESSFUL MANAGEMENT OF THE MODERN MACHINE SHOP AND MANUFACTURING ESTABLISHMENT.

A WORK FOR THE ARCHITECT, ENGINEER, MANUFACTURER, DIRECTOR, OFFICER, ACCOUNTANT, SUPERINTENDENT AND FOREMAN.

BY

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Member American Society of Mechanical Engineers
Expert in Machine Shop and Factory Organization, Modern Shop Methods
Time and Cost Systems, etc.

SECOND EDITION — REVISED AND ENLARGED

ILLUSTRATED BY TWO HUNDRED AND NINETEEN
SPECIALLY MADE ENGRAVINGS BY THE AUTHOR

NEW YORK
THE NORMAN W. HENLEY PUBLISHING COMPANY
2 WEST 45TH STREET
1917

Composition, Presswork, and Binding
by
The Plimpton Press
Norwood, Mass., U.S.A.

To

MY BELOVED BROTHER ALBERT

AN EXCELLENT MECHANIC

THIS BOOK IS

AFFECTIONATELY DEDICATED

BY

THE AUTHOR

PREFACE TO SECOND REVISED AND ENLARGED EDITION

The remarkable success of the First Edition of this work and its flattering reception by practical designing Architects, Managers, Superintendents, and Shop Men has been very gratifying; and the fact that in no instance had the author received complaints of errors, or serious criticism, has induced the publication of this Second Edition.

New developments in Shop Management have suggested the addition of four entirely new chapters devoted to these subjects, which have been fully illustrated for the especial benefit and use of Managers, Accountants, and Shop Men.

In the preface to the First Edition it was said that "the aim and object of the author in publishing this book is to produce a work suitable for the practical and everyday use of the Architects who design, the Manufacturers who build, the Engineers who plan and equip, the Superintendents who organize and direct; and for the information of every Stockholder, Officer, Accountant, Clerk, Superintendent, Foreman and Workman of the Modern Machine Shop and Manufacturing Plant of industrial America." These conditions have proved so satisfactory that the same objects have been sought in the new matter added in this Second Edition.

The Systems herein given are those which the author has successfully used himself or seen used in actual shop practice and under everyday conditions, consequently they are eminently practical. They are confidently recommended to those having charge of work, as simple, practical, and readily workable.

The author has enjoyed over twenty years of successful management of shops and factories without having in a single instance encountered "labor troubles"; and believes that much of this smooth-running efficiency has been due to his thorough belief in the intelligent initiative and honest pride of the American mechanic in his work. Therefore he deprecates all attempts to formulate systems of management which tend to make "machine-made

mechanics," who do their work in blind obedience to overseeing authority and the tick of the watch of the "speed boss." He believes that whatsoever tends to lower the initiative of the workman and retards his independence of thought along the lines of his work tends to lower his efficiency and consequently his value as a factor in the manufacturing problem.

With this view of the subject this Second Edition is confidently submitted to the manufacturer and his co-workers.

OSCAR E. PERRIGO, M. E.

July, 1917.

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PART FIRST

MACHINE SHOP CONSTRUCTION

CHAPTER I

INTRODUCTION

The fitness of things. Growth and progress of manufacturing interests. The usual results to the manufacturing plant. The unnecessary expense. Value of a comprehensive plan. Progress in construction. The striving of the best. The aim of the Author. Different forms of construction. "Slow burning construction." Special requirements of manufacturing buildings. Wooden beams. Special features. Construction of floors. General rules. Compound beams. Care for the strength of timbers.

The "eternal fitness of things," as well as the spirit of this progressive age, requires that in whatever we design, build, equip, and arrange for the production of our portion of the vast output of the manufactures of the present day, we shall strive to make it the best of its class, and the best adapted for the special uses to which it will be put, the kind of goods or machinery to be manufactured, and the circumstances, conditions, and surroundings under which we are to work.

In a great majority of cases the manufacturing plants of this country have been the result of *growth* and *progress*, more or less rapid, of the business which they were designed to accommodate. Often they began with very meager facilities for the work in hand, with poorly designed and cheaply constructed buildings, and all the conveniences and accessories of the plainest kind. As the business enlarged, greater means were available, and necessity demanded, the buildings were gradually added to and their other facilities increased. Buildings were enlarged by increasing their height, by the addition of wings or the erection of separate buildings, often disconnected and scattered, without any apparent plan or consideration of their accessibility or usefulness.

Thus the establishment became an aggregation of buildings of various sizes and forms, requiring much greater expense for handling stock, material, and product, and an unnecessarily large expense for power by which to operate it, and the entire plant often representing in a general way the worst possible arrangement for economically producing work, or for producing really first-class work at all.

At the same time it represented the total expenditure of a much greater amount of capital than would have been necessary to erect and equip good

buildings, designed and built in accordance with the best practice, and well suited to the necessities of the business.

It may be said that the necessity for comprehensive plans could not have been foreseen at the early time at which the business was inaugurated; which may be true enough, but if the founders had even moderate faith in their enterprise they must have at least expected that it would, in time, considerably enlarge. Therefore, a general plan might have been made and such part of it erected as would make it easy to enlarge by adding from time to time to what was originally built, but always in conformity with the original plan and in development of it.

It may be said that the modern development of the construction of manufacturing buildings has so changed their character that it would have been impossible for the early builders to have profited by the formulating of one general plan for a plant equal to the growth of the business, and the modern conception of what such buildings should be. This is in some measure true, but it does not excuse the seemingly total lack of foresight exhibited in the construction and arrangement of many of the older buildings for manufacturing purposes.

Consequently there are numerous establishments in this progressive country to-day occupying antiquated and rambling structures that have cost money enough for the building of modern works, properly designed for the economical production of a much higher grade of goods or machinery than could be possible to produce in the old plants.

"The world moves," and nowhere is this more apparent than in manufacturing and the building of machinery. That which would satisfy the manufacturer for the purposes of his business even five or ten years ago is among the "back numbers" of to-day. The constant striving for the best was never more in evidence than at the present time, among our up-to-date manufacturers who are able to look beyond the first cost to the greater advantages to be gained later on.

In view of these conditions and the necessities of these progressive times, it is the aim of the following pages to discuss, from a practical standpoint, what is the best design, arrangement, and construction of manufacturing plants erected for the production of a medium-sized class of machinery, considering the matter from the reception of the raw material to the shipping of the finished product.

With this object in view, engravings showing the general plans for suitable buildings, of a size, form, and capacity for the usual work, arranged in compact form, of modern construction, and supplied with all necessary conveniences and facilities for readily and economically handling the material and product, have been specially designed and drawn to illustrate these chapters.

In addition to the original complete plan, various forms of construction of these and similar buildings are illustrated and described. As, for instance, the so-called "saw-tooth" construction of roofs, which has of late become so popular when one-story shops are to be constructed, and the product is such that large areas of floor surface are desirable, and which this method of construction so admirably lights up.

There is also illustrated and described the so-called "slow-burning construction" of buildings for machine shops and other manufacturing purposes, which are favorites with the insurance companies on account of their well-proven capability of resisting the ravages of fire. They are shown of brick and wood construction, and also those built entirely of wood.

The intention of the author is not to follow the design and construction into the special field of the architect by giving all of the details of construction, minute directions for the various parts of the work, or the mathematical calculations that may be necessary in preparing the detail plans for the actual construction. These things must necessarily be done by the architect in each individual case. Yet where figures are given they will be found practical and sufficient for the purposes intended.

The intention is to give such illustrations and information in reference to the special requirements of machine shops and manufacturing buildings as the architect or structural engineer who has had little or no shop experience may not be familiar with; and also to point out to the manufacturer about to construct new buildings, or to change or to reconstruct old ones, many of the necessary conditions and requirements, and to suggest the proper solution of many of the problems that will naturally arise under such circumstances.

CHAPTER II

GENERAL PLANS

The plant confined to a limited space. Compact form, capable of easy expansion. The main building or machine shop. Its general arrangement. The offices. Second-floor plans. The drawing room. The pattern shop. The foundry. Foundry departments. The forge shop. Yard tracks. The power house. The storehouse. The carpenter shop. Stock sheds. Railway facilities. Increasing the capacity of the buildings. Enlarging the machine shop. Two plans. Enlargement of the foundry. Additional power facilities. A larger site desirable.

In the arrangement of the general plans for the buildings composing the plant it is supposed that the amount of land is limited and therefore a compact form is necessary. Of course a much larger area would be advisable, but it is much easier to design the buildings and to arrange them in their relation to each other if we have ample area in which to do so. Therefore, the compact form, capable of easy expansion in any direction, is chosen as likely to be the most useful one to those desiring information on the subjects herein treated.

With this in view cuts showing the general plans for suitable buildings of a size and capacity for the usual work, arranged in compact form, of modern construction and supplied with proper conveniences for handling the material and product, accompany this article. The entire plan requires a site of somewhat less than 300 x 450 feet.

Fig. 1 is a front elevation of the buildings composing the plant.

Fig. 2 shows a compact design to meet cases where the amount of land is limited, and illustrates how all the buildings may be so grouped as to render the handling of materials and transportation of them as simple, direct, and economical as possible.

A railroad track should pass near the works, and from it a branch should be brought closely past the rear and to one side of the collection of buildings. Such an arrangement results in a great saving in the expense of hauling both material and product, and permitting the general arrangement and development of the plan herein proposed.

The main building, or machine shop, is 100 x 375 feet, divided lengthwise into a central portion 40 feet wide and 52 feet high, with side wings or bays

each 30 feet wide. The central portion is open clear to the roof and has a traveling crane of ample capacity moving over its entire length. The side wings are divided into a main floor, on a level with the central portion, and a gallery or second floor; the first being 16 feet and the latter 14 feet high in the clear. This gallery is also built across 18 feet of the front end, thus connecting the two galleries and furnishing a platform by way of which the traveling crane may transfer material and product to and from the main floor. Along the center of these galleries and across the front end runs a tram track, provided with light push cars for facilitating the transfers. Stairways are provided at each end and in the center for conveniently and speedily reaching any part of the shop from floor to galleries and *vice versa*.

Fig. 1. — Front Elevation of Shops for a Model Plant to build Medium Sized Machinery. Scale, one inch equals forty feet.

At the front end of the machine shop proper are the offices connected with and forming a part of it, consisting of two structures 50 feet square, with a driveway space of 20 feet between them. On the first floor of one of these are the offices, storeroom, etc., and in the other the tool-making room, a room for storage tools and fixtures, and a stock room, for small finished parts. On the second floor is located the drawing room, while over the driveway is the pattern shop.

The offices are only those particularly connected with the manufacturing and shipping, and not the general offices of the company. A wing connects the front buildings with the foundry. The ground floor of this wing is used as a storage

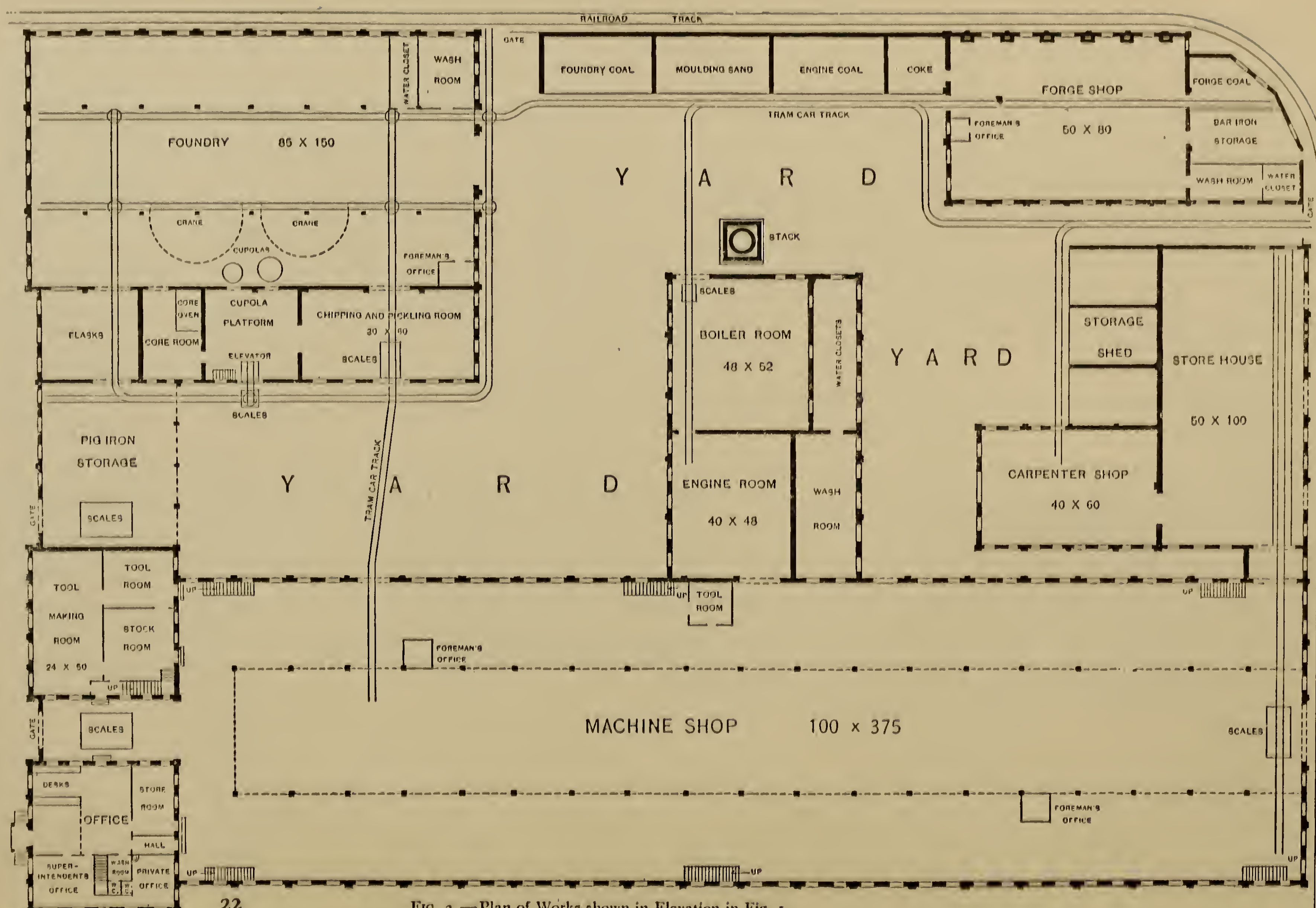


FIG. 2.—Plan of Works shown in Elevation in Fig. 1.

room for pig and scrap iron, and a flask room, while the second floor is a pattern storage loft, connected at one end with the pattern shop and at the opposite end with the foundry by a trap door 8 x 18 feet, directly over the train track leading through the flask room.

The foundry is 85 x 150 feet, arranged with a central part 35 feet wide and two side wings or bays, each 25 feet wide. The central part is covered by a traveling crane running the entire length. There are two cupolas, a large and a small one, served by two cranes of sufficient reach to swing into the central space covered by the traveling crane.

Large work is cast in the central space or within reach of the cranes, while small work and bench molding occupy parts of the floor not covered by the cranes. On each side of the central part are tram tracks, which are crossed by one running to the flask room and one that goes through the chipping room and on across the yard to the machine shop.

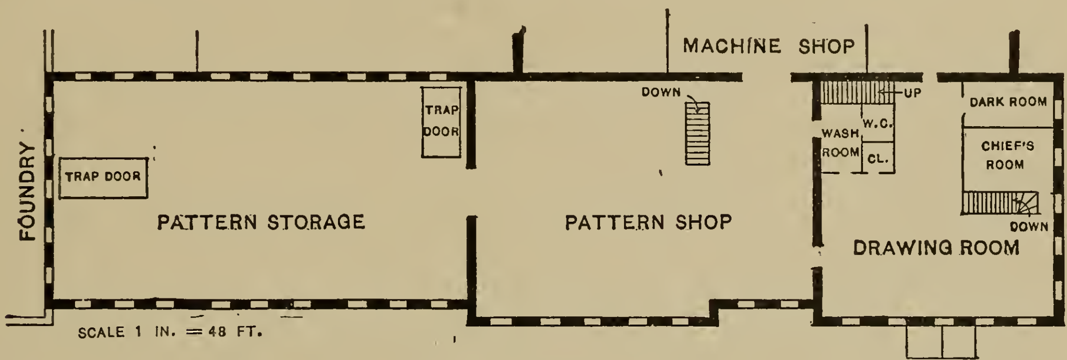


FIG. 3. — Plan of Second Floor of Front Building. Scale, one inch equals forty-four feet.

A wing built on the side of the foundry toward the machine shop contains a platform upon which coal and iron for charging the cupolas are delivered by a tram car raised to that level by an elevator arranged for the purpose. This stock is weighed on track scales in front of the elevator. Beneath the cupola platform are the tumbling barrels, convenient to the cupolas for working over the slag, and to the chipping room for cleaning small castings.

The flask room is located at the front, while between it and the tumbling barrel space is the core room, containing a suitable core oven. At the opposite end, facing the yard, is the chipping and pickling room, where the castings brought in from the foundry are pickled, chipped and weighed, before being sent to the machine shop. If the castings are too heavy for convenient handling in the chipping room they may be run through to the yard and there handled by a boom crane covering the tram track upon which they are run into the machine shop. Castings of moderate size, yet too heavy to move by hand, are expeditiously handled by a light overhead trolley hoist in the chipping room.

At one end of the outer wings are the wash room and toilet. If more

floor space is needed these may be located in a gallery placed 8 or 10 feet above the foundry floor.

In the further corner of the yard, as far as possible from the foundry and engine room, is the forge shop, 50 x 80 feet, which is reached by tram cars, the track running through its length near the center. On the outer walls are the chimneys for the forges and heaters, and in the rear are the storage shed for bar iron and steel, the wash room, toilet, and space for coal. These adjuncts are in a shed built with brick walls and of such outline as to conform somewhat to the curve of the railway track, the forge shop having been so located as to admit of this arrangement.

When down-draft forges, served by exhaust fans, are used, it will not be necessary to build more than one chimney, the flue of which should be large enough to carry off the smoke and gases from all the forges.

The power house is located midway in the length of the machine shop, so that power may be applied to the line shafting at a point that prevents much of the torsion incident to long lines of shafting driven from one end. This building is 65 x 100 feet and contains the engine room, 40 x 48 feet, the boiler room, 48 x 52 feet, and also the wash room, and water-closets used by workmen in the machine shop.

Near the boiler room is the chimney stack, with which the smoke flues of all the boilers are connected. Coal is brought in on push cars along the tram track, to the front of the boilers, where a track scale is placed for weighing it. Ashes are removed by the same tram track to whatever point is most desirable to deliver them.

Across the rear end of the yard is the storehouse, 50 x 100 feet, for finished machines, or product. This connects with the rear end of the machine shop by a tram track running from the scales beneath the traveling crane through a wide doorway and the entire length of the storehouse. The rear side of the storehouse (next to the railway track) has wide, sliding doors, through which the finished product is readily moved into the railway cars for shipment. Here, as in the chipping room of the foundry, it may be desirable to make use of overhead trolley hoists to facilitate rapid and economical handling of machinery to be shipped.

A 12-foot space is left between storehouse and forge shop for a branch of the tram tracks, as a convenient means of receiving material from the railway at this point.

Adjoining the storehouse is the carpenter shop, 40 x 60 feet. Thus the men who prepare the finished machinery for shipping are near their work, and the lumber used for this purpose, and the necessary machinery for cutting it up, are close at hand and require no unnecessary handling.

In the angle formed by the storehouse and carpenter shop are the storage

sheds for cast iron and steel chips from the machine shop, or for similar materials.

Along the side of the yard, and extending from the forge shop to within 20 feet of the foundry, are arranged the stock sheds. These hold foundry sand and coal, engine coal, coke, etc., which is delivered into them directly from the railway cars, the track being raised to the proper grade after it has passed the storehouse. It is continued the whole length of the foundry so as to deliver foundry sand directly into the windows of the foundry if desirable, keeping that in the storage shed as a reserve supply.

Between the storage sheds and foundry is a gate, through which may pass a branch of the tram car track for receiving stock and material from the railway cars at this point.

Details of the plans herein outlined and the progress of the work from the raw materials to the finished product will be given in future chapters. The second chapter will deal especially with the construction of the buildings.

Whatever may be the dimensions of the building of a manufacturing plant, or however carefully provision be made for all necessities for handling materials, etc., there is always the possibility, and frequently the probability, that some day the works will have to be increased in capacity or changed in form.

It is, therefore, important to consider these points at the outset, and to provide for an expansion of the business in accordance with future needs, and at the same time not to disarrange or break up the general plan of the works. With these points in mind, the two following plans are given for enlarging the machine shop when more room is needed:

First, the building may be extended to the rear across the railway track, the rear wall being removed and the traveling crane tracks continued through the length of the additional building. Doors are provided for the passage of cars upon the railway track, and also a specially-built car habitually used for connecting the floors of the old and new building, its platform being on a level with the two floors. Thus the machine shop capacity could be increased to any reasonable extent.

Second, one, two or three wings may be built at right angles to the machine shop and on the side opposite the power house. These might be of one or two stories and of any desired length. They may contain traveling cranes to convey material to and from the traveling crane of the main shop, or have convenient trolley hoists and train car tracks, according to the character of the work to be done.

The capacity of the foundry may be increased one third by extending it toward the power house. The same space may be obtained by using for foundry space that provided for chipping, core, and flask rooms, and provid-

ing space for the latter by extending the building toward the machine shop. The space occupied by the wash room and water-closet will, of course, be taken also, and these rooms placed in a gallery, as heretofore suggested.

To obtain additional power space for these enlargements the space occupied by the wash rooms and water-closets may be utilized and these rooms provided for in an addition built toward the carpenter shop.

By some one of these plans, or a combination of them, the capacity of the works may be at least doubled without seriously disturbing the general plan here described and illustrated and without impairing the general efficiency of the facilities for handling the work.

This design is in as compact a form as is advisable, with a view of sufficient yard space. Where the amount of land is ample it would be manifestly desirable to spread out the design more by increasing the distance between the machine shop and foundry at the front, and the storehouse and forge shop at the rear; or by lengthening the machine shop 50 to 100 feet and thus add to the yard room.

Either or both these plans might be employed where the extent of ground would admit of it, as it is always important to have plenty of room when it is possible, and it is seldom that we have too much yard space.

CHAPTER III

GENERAL CONSTRUCTION OF THE BUILDING

Principal requisites. Should be erected for utility rather than ornament. Special requirements of manufacturing buildings. The best type of buildings for the purpose. The construction of the walls. Sham work. Methods of laying bricks. Window spacing. Roof construction. Protection from condensation. The central portion of the machine shop. The traveling crane. Side portions or bays of the machine shop. The galleries. Dimensions of walls. The foundry. General dimensions. Central part. Side bays. Cupola platform. The forge shop. General dimensions. Roof ventilation. Chimneys. The power house. Alternate plans. The engine room. The storehouse. Special construction of floor. Trolley hoists and supports. The carpenter shop. Storage sheds. Coal and sand sheds. Floors of storage sheds. Forge shop storage.

Having arranged and planned the buildings for carrying on the work for which our plant is designed, making each of a size large enough for the equipment to be installed and the number of men required to operate it, and having placed the several buildings in convenient adjacency for economically passing the work through them, from the raw material to the finished product, let us now consider the construction of the buildings planned.

Manufacturing buildings are erected for utility rather than ornament, and the latter characteristic is always made secondary to the practical question of best fitting them for the special work to be done in them. To this end one must be guided by several well-known conditions.

First, the buildings should be strong enough to bear the weight and withstand the strain of the machinery operated in them, and the materials used in manufacturing, with which they are loaded. This load frequently varies within a wide range as to weight at different times, and is also constantly being shifted from one point to another, so that ample provision must be made for this condition.

Second, the building must be of such construction as to be amply rigid for all purposes, and to a certain extent be elastic enough to remain uninjured under the shocks that it is liable to undergo.

Third, there should be ample opportunity for ventilation, yet not unnecessary height, as the expense of heating would be needlessly increased.

Fourth, ample provision should be made for light, for which purpose the

windows should be placed at short intervals and extend nearly to the ceiling. At the same time an extravagant use of glass will also greatly increase the cost of heating.

Fifth, the floors should be of such strength and material as to bear whatever weight is to be put upon them, either regularly or temporarily.

Sixth, numerous exits should be provided for the use of employees in case of fire. This becomes more imperative as the number of employees increases in proportion to the area of floor surface; as for instance, in factories, particularly where boys and females are employed.

Seventh, the roofs should be so constructed as to bear the weight of snow in winter, as well as the pressure of high winds; and they should be so designed as to give a minimum amount of after-expense from deterioration and from leaking, the latter cause usually costing much more from damage to stock and machinery than for repairs to the roof itself.

For manufacturing buildings in general there is probably no construction more satisfactory in every respect and that answers all the usual conditions better than brick walls and an iron roof. The walls should be of a thickness proper to the dimensions and purposes of the building, and, except when the building is for light work, should be strengthened by buttresses placed between the windows or groups of windows.

In the building of brick walls much care should be taken as to the method of laying the bricks. It is too often the case that the wall is really two walls with little or no substantial connection between them. A "face" is laid up to the face line, and the "backing" even with the back line of the wall. If this leaves a space, from the regular size of the bricks failing to reach each other, it is frequently left as it is without being filled with pieces of bricks, or even with mortar. This space is not bridged over at as frequent intervals as it should be by header courses, so that we have what is practically a sham piece of work.

It is one of the too prevalent customs, also, of filling only an inch or so of the face of the joints between the ends of the bricks with mortar. This is another form of sham work, and neither of the above practices should be allowed.

Where very strong walls are desired, as for the brick foundation walls for buildings, or foundations for heavy machinery, the bricks should be laid in what is called the English bond, that is, the courses will be composed of an alternate header and stretcher brick. On the next course the header is laid across the center of the stretcher brick.

Another method is the Flemish bond, which consists of alternate courses of headers and stretchers.

For the side walls of shops generally, the bricks should be laid with a

header course to every five stretcher courses. It is often the practice that the stretcher courses are increased to seven instead of five, and we remember one old bricklayer who, in bemoaning some of the modern sham work, said that "they put in a header course every Tuesday."

In spacing brickwork for the windows it is customary to lay them off so as to take a certain number of whole bricks, or a certain number of lengths of bricks, with the width of one brick to fill out the space required. By this means much cutting of bricks is avoided, and the face of the wall appears much more neat and regular. In laying out the plans for buildings this matter should be considered.

In all cases the wall should be frequently leveled crosswise, as well as lengthwise, to insure a fair horizontal bearing for all the bricks, as even a slight inclination greatly endangers the strength of the wall.

The roof [1] proper should be supported by trusses at each division or bay, and connected by purlins, all securely braced; by which construction lightness, combined with great strength and ample elasticity, is secured. For a covering, wood may be used and covered with roofing tin which should be always protected by a good coating of mineral paint.

The covering may be of corrugated iron, although this has the very serious objection of moisture condensing on its underside and dripping into the interior of the building. This may be wholly prevented by laying on a couple of thicknesses of tar paper, or other paper impervious to water, and as a protection against fire from the underside of the tar paper, first laying two thicknesses of asbestos paper. These four layers of paper are supported by galvanized wire netting, tightly stretched over the purlin supports.

This is probably the best form of roof covering yet devised for the roofs of manufacturing buildings, and with brick walls, truss roof, and covering as described the building is practically fire-proof.

Referring to Fig. 4, the machine shop is seen to be constructed with a central portion 40 feet wide and covered by a traveling crane, giving a clear height of 40 feet beneath it. This crane is supported by wide plate girders resting on the main columns, and runs the entire length of the machine shop. It may be operated by belting and gearing, but preferably by electricity, as the necessary power is much more readily transmitted to any point in the length of the building by conducting wires and a suitable trolley than by means of shafts and belts with their attendant expense and annoyance.

On each side of the central portion of the building are wings 30 feet wide, extending the whole length of the structure, and built in two floors, the upper one, or gallery, being used for light machinery. It extends across

[1] The roof designs shown are substantially those adopted by the Berlin Construction Co., New Britain, Conn.

the front end, both as a means of conveniently connecting the two galleries and of affording a platform for transferring stock, materials, or machines to and from the ground floor by the traveling crane.

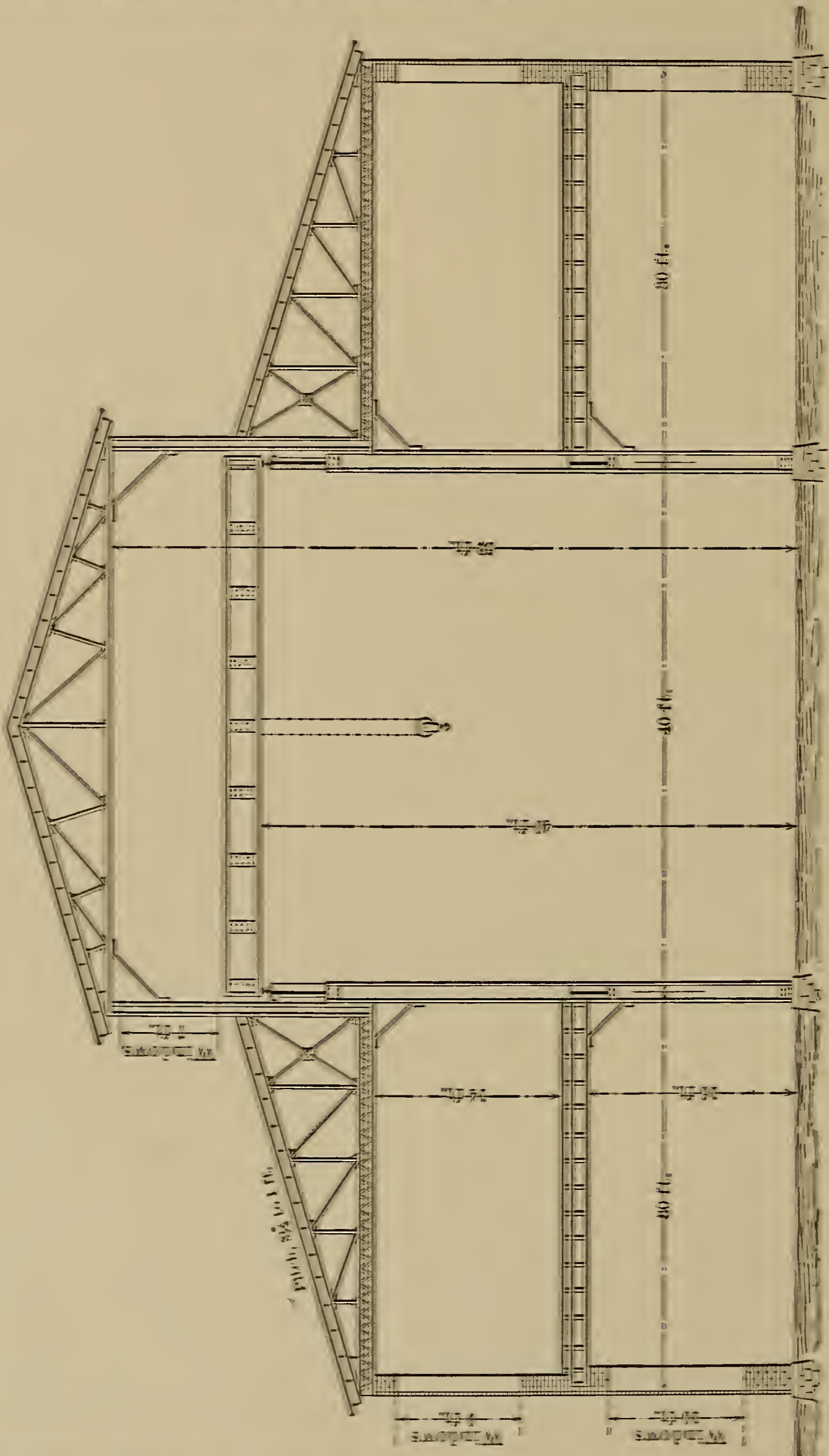


FIG. 4.—Cross Section through Machine Shop.

The lower member of the roof truss is of latticed form, to give the required strength for supporting the lines of shafting. The floors of the galleries are

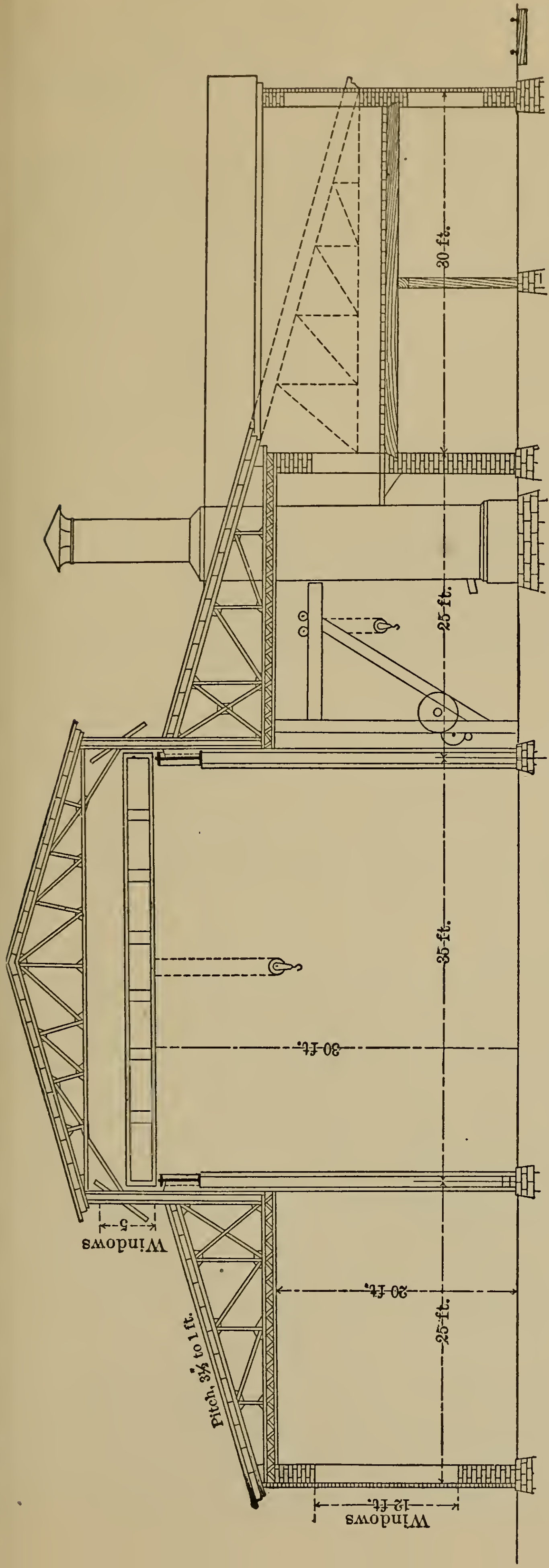


Fig. 5. — Cross Section through Foundry, Cupola Platform, etc.

supported by girders, upon which floor joists are supported, and to the under side of which the line-shaft hangers are attached.

The side walls are built 20 inches thick for the first story, or 16 feet, and 16 inches thick for the remainder of the height, and are strengthened by buttresses of 8 inches projection and 24 inches wide. Each bay, or division, is 18 feet 3 inches centers, and the side wall is pierced for two windows on each floor, each window being 4 feet wide; the lower ones 10 feet, and the upper ones 9 feet high.

Above the wing roofs is a monitor roof construction having another series of windows 5 feet high, extending the entire length of the building and separated one from the other only by about 12 inches, thus giving ample light to the central portion of the building. Every alternate sash is pivoted so as to be opened for ventilation.

The roof is constructed as has already been described, with an outward covering of corrugated iron, and has a pitch of $3\frac{1}{2}$ inches to the foot, as have the roofs of all the buildings of the plant. The form of truss is the usual one, as shown in the engravings.

The foundry is built on a

plan similar to that of the machine shop, with a central part 35 feet wide and side wings 25 feet wide each. On the cupola side the wing proper is extended 30 feet further, to furnish accommodations for the cupola platform, chipping, core, and flask rooms. See Figs. 5 and 6.

The central part of the foundry is covered by a traveling crane supported by plate girders resting on the main columns and having a clear space of 30 feet beneath it, while the side wings are 20 feet in the clear. The operations of the foundry do not require this height, but it is very desirable to have ample space for the steam and gases, incident to "shaking out" the flasks after pouring off, thus adding much to the comfort of the men.

To further facilitate the exit of these gases, the upper windows 5 feet in height, opening over the roofs of the side wings, are all made with pivoted sashes, so as to be readily opened when necessary.

The bays or divisions between columns are 18 feet 6 inches centers. The side walls are 20 inches thick, strengthened by buttresses of 4 inches projection and 18 inches wide, and each bay is provided with two windows 4 feet wide and 12 feet high, affording ample light to the side wings and, by the aid of the ventilator windows in the monitor roof construction, completely lighting the whole interior.

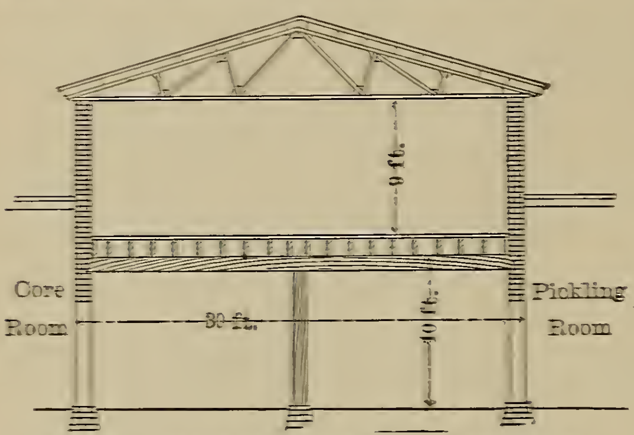


Fig. 6. — Section through Cupola Platform at Right Angles to Fig. 5.

The lower member of the roof trusses for the side wings is of latticed form to afford sufficient strength for supporting the cranes, and for trolley hoists at any point where they may be needed.

The cupola platform construction is shown in cross-section in Fig. 5 and at right angles with this in Fig. 6. A floor supported by suitable timbers forms the cupola platform proper. This may be constructed entirely of iron, if desired, in order to lessen the liability to damage by fire. The platform should be covered with sheet iron, at least in the immediate vicinity of the cupolas, and should be placed at a proper height to suit the cupolas used. It may be reached by way of an elevator carrying one of the yard tram cars, as will be described hereafter in another chapter.

The forge shop is built much heavier in proportion to its size than the other buildings, on account of the strains and shocks caused by heavy hammers and drop presses. It is 50 feet wide, 80 feet long, and 18 feet high in the clear, and no columns or other obstructions interfere with the free working. The

roof girders are strongly built and thoroughly braced, and the lower member made in latticed form for supporting the usual overhead work of the shop as shown in Fig. 7.

The walls are 20 inches thick and 18 feet high, strengthened by buttresses 8 inches thick for a height of 8 feet, and for the remaining height 4 inches thick by 20 inches wide. The spaces or bays are 13 feet centers and the wall is pierced for one window to each space. The windows are 4 feet wide and 12 feet high, and located, five on each side, three in the front and one in the rear, making fourteen in all.

The roof ventilator is 12 feet wide and extends the entire length of the building, with openings $4\frac{1}{2}$ feet high, as shown in Fig. 7.

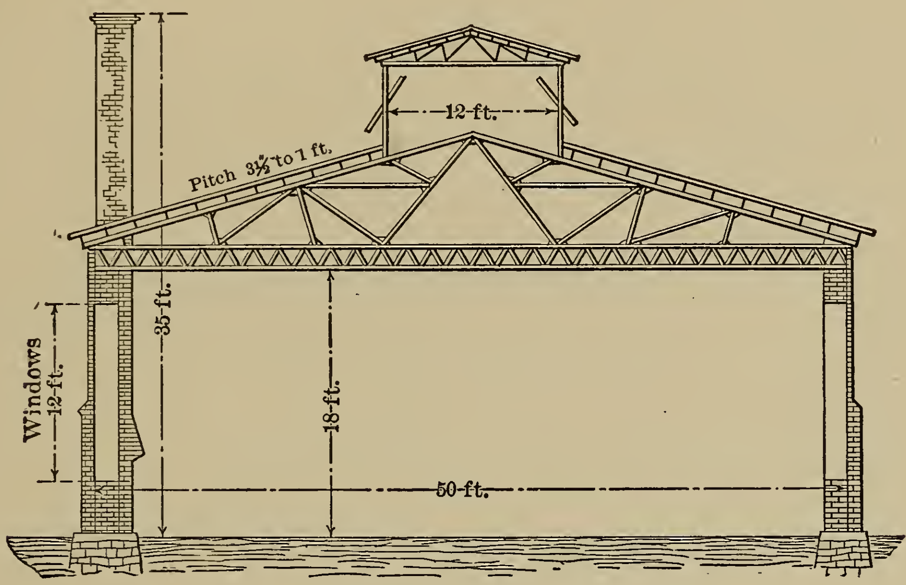


Fig. 7.— Cross Section through Forge Shop.

Along the outer wall are arranged chimneys for six forges. If the system of downward draft is employed these would not be needed, the smoke and gases from all being carried to one chimney of sufficient dimensions and conveniently located for that purpose.

In consequence of the arrangement necessary for these chimneys, when such construction must be used, the buttresses on this side are placed opposite the chimneys and the windows between. This necessitates the use of a steel I-beam in the wall over the windows for supporting the roof trusses. By reducing the number of chimneys to five, this may be avoided.

The power house is of construction similar to the other buildings. The walls are 16 inches thick and 20 feet high, with buttresses 4 inches thick and 20 inches wide. 12-inch walls divide the boiler room, engine room, water-closets and wash rooms from one another, the last two being built in two floors — the lower one 10 feet and the upper 9 feet high, in the clear. There is a ventilator of monitor construction, 12 feet wide, running the whole length

of the building, with pivoted window sashes on each side, 5 feet high, shown in Fig. 8.

When the power required would render it necessary the entire building might be devoted to the boiler and engine room, and the wash rooms and water-closets be provided for in a side addition. They are placed as shown in order to secure a central location and immediate connection with the machine shop without encroaching upon its space.

Plenty of light is provided for the wash rooms and water-closets by rows of ten windows, 3 feet wide, on each floor, the upper ones being $5\frac{1}{2}$ feet and the lower ones 6 feet high.

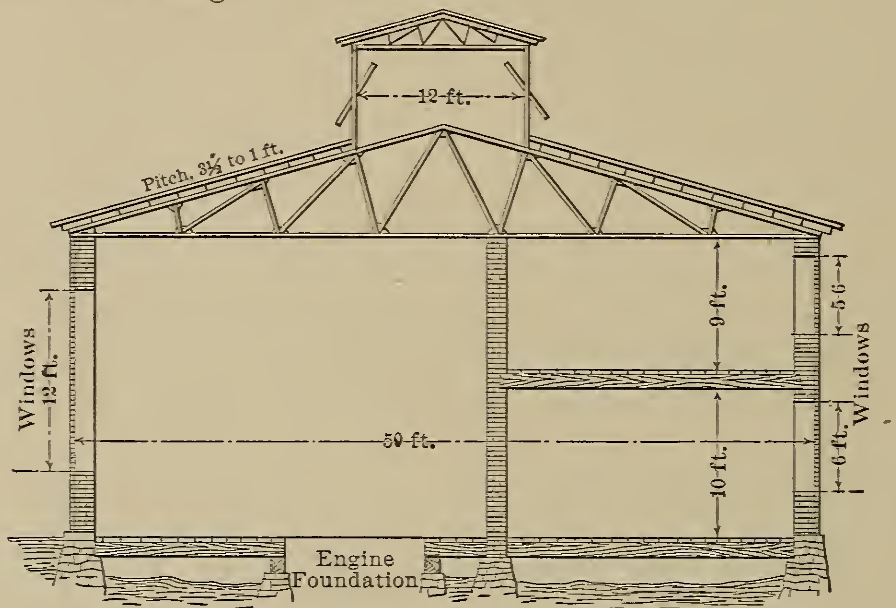


FIG. 8. — Cross Section through Power House

The engine room and also the boiler room are lighted by four windows, 4 feet wide and 12 feet high, in the outer wall; while two extra windows are placed in the end of the boiler room for the purpose of giving ample light in the rear of the boilers.

In the end of the boiler room is a double door 12 feet wide, one half of which only need be opened to admit the coal car. Near this door are the track scales for weighing the coal as it is brought in. The tram track is continued the length of the boiler room, in front of the boilers and through the door into the engine room, as a convenient means of bringing in or taking out any small machines such as dynamos or similar apparatus.

The engine room connects with the machine shop by an opening 14 feet wide and 16 feet high, through which engines or large pieces of machinery may be moved, and through which main belts may be run. This space may be closed up, after the power plant is installed, either by doors or by a wooden partition containing suitable doors.

The storehouse for finished machinery, and the carpenter shop adjoining,

Fig. 9, are of the same general construction as the other buildings, so far as the walls and roofs are concerned. Both have 16-inch walls, 14 feet high for the carpenter shop and 18 feet for the storehouse, and strengthened by buttresses of 4 inches projection by 16 inches in width.

The storehouse floor is 3 feet above the level of the machine shop floor. Near the back wall (next to the railway track) the floor is cut out and a specially constructed tram car traverses the space, the top being on a level with the floor.

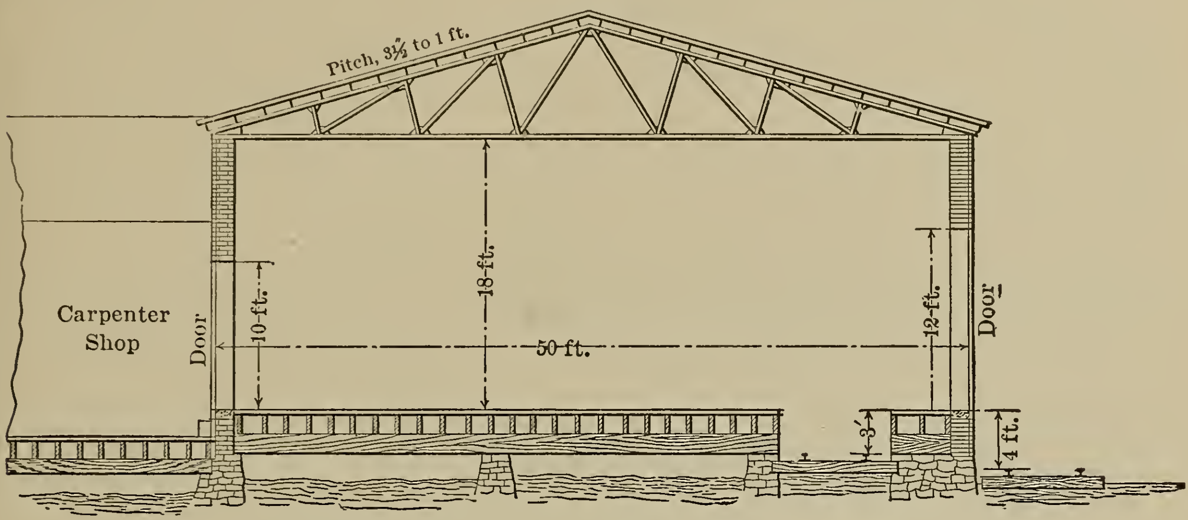


Fig. 9.— Cross Section through Storehouse, Carpenter Shop, Tracks, etc.

This car track crosses the machine shop floor, and passes over the scales located in it, directly under the traveling crane. By this arrangement machines may be transferred from any point in the shop to this car, standing on the scales, and may be weighted, run into the storehouse and stored away or conveniently run into a car on the railway track, the top of the cars being also on a level with the storehouse floor.

In case the machinery built is of sufficient weight to make such an arrangement desirable, the lower member of the roof trusses should be of latticed form, or, if needed, several of them may be plate girders, on which may run trolley hoists for lifting a machine from the tram car and running it back into the rear of the storehouse or out upon a railway car. The girders may project out over the railway tracks sufficiently to permit of easy handling in loading cars.

Two sliding doors, one of 8 feet and the other of 12 feet in width and both 12 feet high, are provided for shipping convenience. The storehouse is lighted by eleven windows, each 4 feet wide and 10 feet high.

Additional windows might be located in the rear wall, over the storage sheds and in the end toward the forge shop if the machinery manufactured was of such small size and such variety as to make a division of the storehouse necessary to properly store and care for it.

The carpenter shop is provided with a sliding door, 6 feet wide, in the side where a branch of the tram tracks enters, and one in each end 10 feet wide. The shop is lighted by thirteen windows, $3\frac{1}{2}$ feet wide and 6 feet high. The roof trusses are placed 15 feet from center to center, the lower members of which may be latticed to afford support for the shafting driving the wood-working machinery. See Fig. 10.

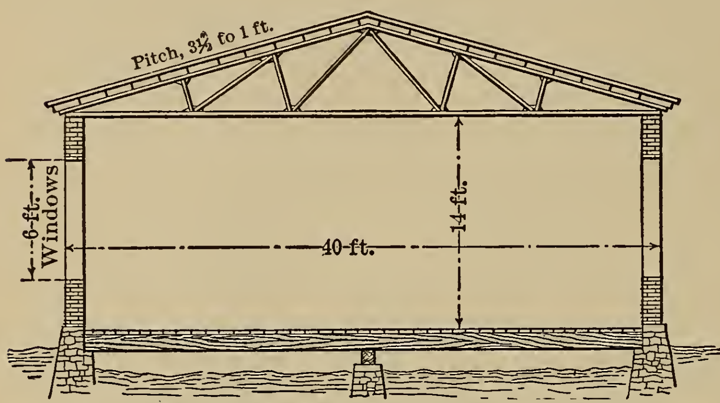


FIG. 10. — Cross Section through Carpenter Shop.

The storage sheds for coal, sand, coke, etc., as well as those for cast iron, steel chips, and similar materials, may be built of wood, but a brick construction will be found to be much more satisfactory.

The walls should be 12 inches thick and 8 feet high on the side next to the yard. The roof may be what is termed a "gravel roof"; that is, consisting of wooden rafters covered with 1-inch rough boards, over which is placed tarred paper, then a coating of well-boiled gas tar, and upon this a layer of gravel stones of from $\frac{1}{8}$-inch to $\frac{3}{8}$-inch diameter and perfectly free from dirt. This roof should have an inclination of $\frac{1}{2}$ inch to 1 foot.

For the coal and sand sheds the openings in the walls may be 3 feet high, beginning just under the roof, and 6 feet wide, on the side next to the railway track. These should be closed by hinged doors of two thicknesses of $\frac{7}{8}$-inch boards, the grain of each thickness crossing the other at an angle of 45 degrees.

On the side of these sheds, next to the yard, sliding doors, hung from the top and usually not over 10 feet wide, are most practical. To be substantial they should be made as described above, of two thicknesses of $\frac{7}{8}$-inch boards, and so arranged that each alternate door will slide in front of the others.

Inside of these and about a foot from them planks 12 inches wide and from 2 to 3 inches thick should be set on edge, to sustain the weight of material behind them. These should be fitted in grooves at the ends so as to be easily removable, as occasion may require, and they may have as a central support a scantling set in a hole in the floor and properly supported at the top.

The floors of these sheds may be of 2-inch planks, supported by scantling 4 x 4 inches, laid 18 inches from center to center. But much better than this, and cheaper in course of time, will be brick paving, laid as will be described in the chapter on floors.

The construction of the shed in the rear of the forge shop should be as

described above, except that there will be wood floors for the wash room and water-closets.

The questions of foundations and floors have been here omitted, and will form the subject of other chapters, wherein will be considered various forms of foundations for various purposes and of floors, both of wood and other materials, and wherein some of the reasons for the failure of many of them now in use will be pointed out.

CHAPTER IV

SLOW-BURNING CONSTRUCTION [1]

What it is. So called fire-proof buildings. The failure of the older forms of construction. The reasons why. Wrong choice of materials. Wrong ideas of the proper construction for manufacturing buildings. Economy of the system of slow-burning construction. Special features of the system. Construction of floors. Concealed spaces. Brick walls. Ceilings and wooden walls. Kalsomining. Compound beams. Care of main timbers. Wooden columns.

MUCH has been said and written and many millions of dollars have been spent in the effort to construct fire-proof buildings.

Buildings have been constructed almost entirely of iron, steel, and glass; magnificent in appearance and costing princely sums of money to erect. They have been popularly called "fire-proof," yet the burning of their contents, or the effects of the conflagration of buildings near them, have so warped, twisted, and bent the metal work of their construction as to leave them a mass of unsightly ruins, a veritable scrap heap of old iron and steel.

Fine buildings have been constructed of solid granite, splendid in proportions and costly in their erection, and that seemed designed to stand for ages. Yet the excessive heat from the burning of buildings by which they were surrounded, and the action of the water from the firemen's hose on their heated surfaces, have practically destroyed them.

And in fact, in a great many cases less prominent than those above mentioned perhaps, expensive structures, apparently impregnable to the destructive action of fire, have fallen a more or less easy prey to the first serious conflagration that assailed them, and the hopes of their well meaning and conscientious designers have been doomed to disappointment, and their owners to those serious losses which no amount of insurance ever covers.

Such have been the results of the patient and really able efforts of many conscientious architects. Nor have the efforts of these builders in the past been more astray on the matter of *materials* with which to construct buildings, to resist the ravages of fire, than in the matter of form and detail in designing

[1] The information necessary for describing and illustrating the type of buildings known as "Slow-burning" has been derived from the excellent reports of the Insurance Engineering Station, Boston, Mass. under the able direction of Mr. Edward Atkinson, an acknowledged authority on this subject.

them, not only to be safe from fire, but practically useful for the purposes for which they were intended.

Of the older construction of buildings where more attention was sometimes paid to appearances than to practical usefulness, and roofs were built in such ornate style and so ornamented with turrets, peaks, and dormer windows as to be hardly recognized as manufacturing buildings, it is gratifying to know that they are now things of the past, many of them having been destroyed by fires, invited by their faulty construction, and the wisdom thereby gained by costly experience preventing their reproduction.

But after years and years of the study and effort of many good men in this field, it is still an open question whether we shall ever get to the point where we can construct a building adapted to the practical wants of manufacturing operations that we can say is really fire-proof.

Such being the result of so much effort and expense in seeking for that which has, thus far, not been attained, it would seem wise to rather lower the standard of what is aimed at, and, instead of striving to build actually fire-proof buildings, to endeavor to design the best form of a slow-burning construction.

In so doing we will do well to remember some of the more important things learned by the experience of the past.

While it is doubtless true that many of the so-called fire-proof buildings might also be denominated slow-burning, yet it is also true that slow-burning construction, as now generally understood, is of a much more economical and simple form, and in a large majority of cases consists of wood and brick, and sometimes of wood alone.

To such an extent is this true that many of these buildings are constructed, the several stories being taken into the account, at a cost of less than eighty cents per square foot of floor surface, while the factor of safety is very high.

It has been amply proven that while a steel post or column may be sprung so badly during the early stages of a fire as to fail to sustain its load, a wooden post would not be burned through, but would continue to perform its office.

Wooden beams that in a protracted fire may burn through and allow the floor to drop, will ofttimes not do as much damage as is caused by the twisting of steel girders, which, becoming distorted, force other parts out of place and destroy portions of the walls on which they rest.

The special features of slow-burning construction may be said to be: so disposing timber and plank in heavy, solid masses as to expose the least number of corners or ignitable projections to the action of fire, and in such a manner that when fire does occur it may be most easily reached by the water from the sprinklers, or from the firemen's hose.

When several floors are necessary they are separated as much as possible

by automatically closing hatches for elevators, by protecting stairways with non-combustible partitions, by avoiding light wooden partitions as much as may be, and by avoiding varnish or other rapidly burning finish on ceilings or floor timbers.

Floors should not be supported in the usual manner by joists placed closely together, but should be constructed of 3-inch planks, supported by beams placed about 8 feet centers. This will give free play to the water from the sprinklers, or the sweep of the water from the fire hose. It is a fact that in buildings having deep floor joists, placed closely together, one side of these timbers may be actively burning while the water is pouring on the opposite side.

Care should be taken to avoid concealed spaces where fire may exist and water from a hose or the sprinklers may not freely enter.

Brick walls should not be covered or sheathed with wood, and in cases where this cannot be avoided, the spaces between the wall and the sheathing should be as small as possible.

Ceilings, or wooden walls, may be effectually protected by covering them with expanded metal, wire lath, or dovetailed laths, and plastering with a hard, plain lime-mortar, which is sufficiently porous to permit the seasoning of the woodwork to which it is attached.

It is better to avoid the use of oil paint or varnish entirely, on the interior of manufacturing buildings, on account of its retaining all of the moisture that may happen to be in the wood, and so hastening the process of decay. Kalsomine, whitewash, or the water paints, so-called, are porous and consequently allow the seasoning process to go on unimpeded.

But as a rule, timbers may be left unprotected except in places very dangerous on account of fire, since any fire which will seriously impair or destroy a heavy timber will already have done its work by destroying other and lighter parts of the structure.

In many instances it may be desirable to substitute compound beams for single timbers. These are made by placing two or more beams or planks side by side and securing them by through and through bolts. It is frequently easier to obtain well-seasoned lumber of the smaller dimensions, and any weak place in one is supported and reinforced by the other when secured to it. Ordinarily the thickness of such timbers should be from one third to one half their width. In building up a compound beam, the separate timbers should be placed slightly apart, so as to permit ventilation to their surfaces, and thus render them less liable to decay.

The main timbers should not be cut into more than is absolutely necessary for securing braces, the support of horizontal timbers, and for similiar purposes, as the timbers are very materially weakened by even a slight cut. For

the same reason, no more holes for bolts, rods, etc., should be bored in the timbers than is really necessary to fasten them together, or to aid in supporting other timbers. Holes used for bolting together compound beams should be located, not opposite each other, but in a zig-zag form.

Wooden columns or posts should have a hole, say one inch to one and a half inches in diameter bored through their entire length, and then connected with the outer air by two half-inch holes bored through the column near either end. By this method, the moisture originally contained in them may have an opportunity to evaporate.

CHAPTER V

SLOW-BURNING CONSTRUCTION OF BRICK AND WOOD

The most substantial form. Clearly shown in the engraving. Strength necessary. Vibration. Dimensions of timbers. Dimensions of walls. Wall plates. Dimensions of supporting posts. Special construction of floors. Dimensions of floor timbers. Roof construction. Gutters not necessary. Conductors. Windows. Application of gutters to buildings of over two stories in height. Nominal dimensions given.

The most substantial method of erecting a building of the slow-burning type of construction is with brick walls, properly strengthened by pilasters, or buttresses, and the interior work, floors, and roof composed almost entirely of substantial timbers and 3-inch matched planks.

This form of construction is shown in isometrical perspective in Fig. 11. The vertical section of the walls is made through the pilasters, between the windows, the thickness of the walls of the panels being according to their height and width. In this case only two floors are shown, but any reasonable height may be constructed in the same manner, provided that the walls of the lower floors are thickened according to the height, and that the central supporting posts are proportionately larger for the lower floors.

Consideration should also be given to the strength necessary to support any unusually heavy machinery that is to be placed on the lower floors.

As the height of the building is increased, the question of vibration becomes more important and additional strength of walls and timbers must be provided to meet it.

For a building of three floors the walls would be about as follows: For light work and no machinery to cause vibration, 16 inches for the first story, 12 inches for the second story, and 8 inches for the third story. For a building for heavier work, and where light machinery is to be used, these figures would be 20, 16, and 12 inches respectively. For higher buildings of say four stories, for light factory work, we may build the first-story walls 24 inches, the second-story 20 inches, the third-story 16 inches, and the fourth-story 12 inches. These should, of course, be strengthened by pilasters in the usual manner.

In all cases where the building is much beyond the usual width, the walls of the top story should not be less than 12 inches thick.

The pilasters should be about 50 per cent thicker at the base than the wall of the first story, and about 50 per cent thicker than the wall of the top

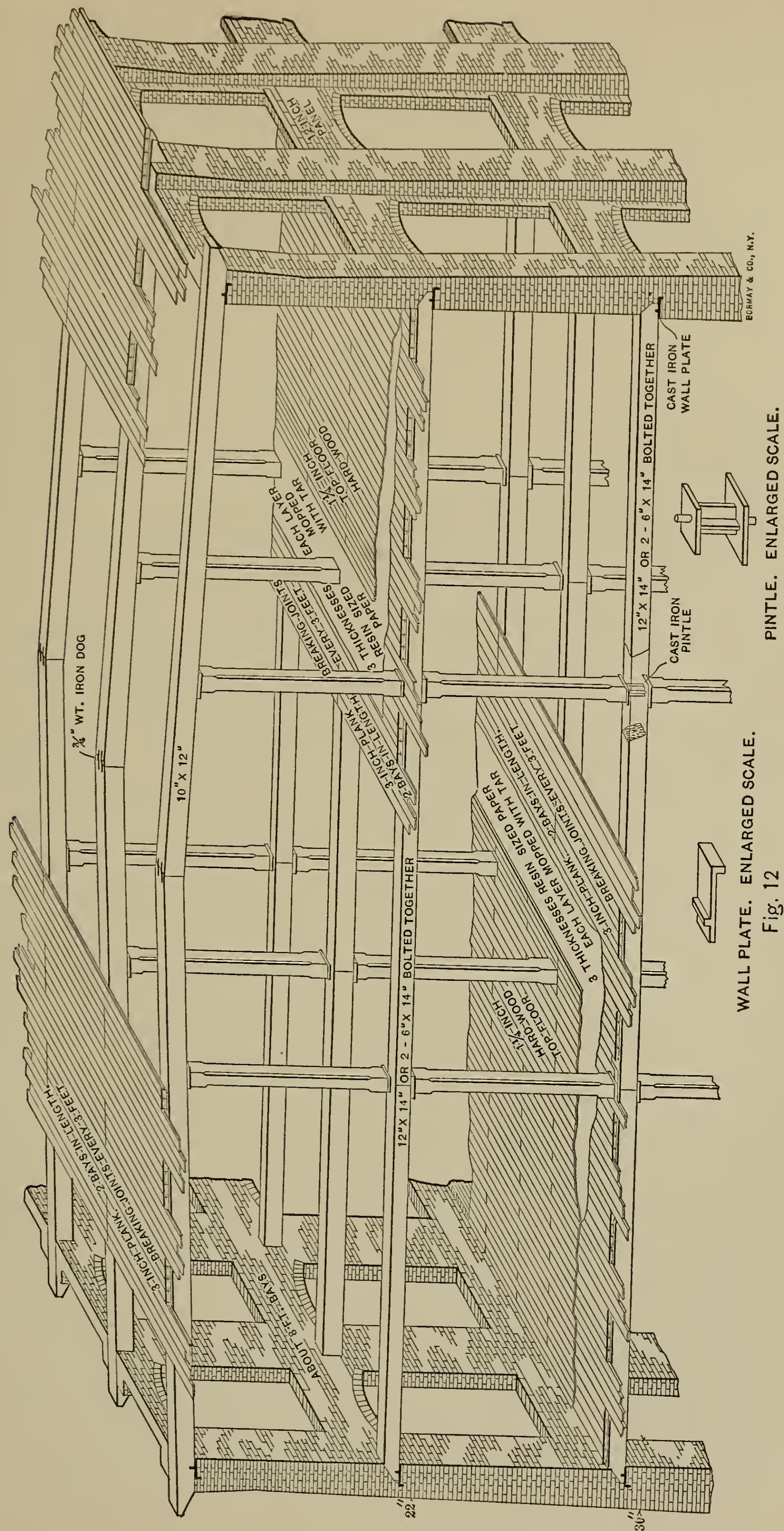


FIG. 11. — Factory Building of Slow-Burning Construction, of Brick and Wood.

story at a point two thirds of the height of the windows. Between these two points it tapers in a straight line, or has a regular "batter." From this upper point it is gradually thickened till at the top it is double the thickness of the wall. While these proportions are nominal, they are very nearly in accord with the regular practice. Upon these pilasters the floor timbers and the rafters have their bearing.

The walls are built to form bays of 8 feet centers. The floor timbers are beveled off at the ends as shown, where they enter the walls, and rest on cast iron wall plates, one of which is shown on an enlarged scale in Fig. 12. Their inner ends are carried by wooden posts, each of which are cut to the length which the height of the story is to be "in the clear," the space occupied by the floor timbers being taken up by cast iron "pintles" located as shown in Fig. 11, and of the form shown on an enlarged scale in Fig. 13.

By this method the supporting posts will not be disturbed by the burning away of a floor timber, even though it falls and carries a portion of the floor with it.

These posts should be of decreasing dimensions as they go up. For instance, if it is necessary to have them 12 x 12 inches on the first floor, those of the second floor will be 10 x 10 inches, those of the third floor 8 x 8 inches, and those of the fourth floor 6 x 6 inches, assuming, of course, that the weights of stock and material are much lighter on the upper floors, and no machinery employed on the two upper floors. Otherwise the posts should not be less than 8 x 8 inches on the top floor, and increasing in the above proportion on the other floors.

The floors are formed of 3-inch planks, whose lengths may be 16 or 24 feet, and which should break joints every three feet. As a matter of economy, these planks should be grooved on both edges and have tongues of a separate piece of wood introduced. The planks should not be over 6 inches wide.

Upon this floor is laid three thicknesses of rosin-sized paper, each layer being mopped with tar, rendering the floor water-proof. Upon this paper is laid a top floor of 1¼-inch hard wood, which may be at any time renewed when it becomes worn out, without disturbing the stability of the structure.

The floor timbers may be, say, 12 x 14 inches for a span of twenty feet between supports. Compound beams composed of two 6 x 14 inch timbers may be used instead of solid timbers, and in some respects will be preferable, as has been pointed out in a previous chapter.

The dimensions of floor timbers may also be decreased in the higher floors, but not to the same extent as the supporting posts are. Their depth must, of course, have reference to their length, which is constant, as well as to the lighter loads which they are to support.

The edges of the floor planks should be kept clear of the face of the walls by a space of about half an inch, as a safeguard against the expansion of the planks during damp weather. These spaces should be covered by light battens, both above and on the under side.

The hard wood top floor may be laid at right angles with the 3-inch plank, or diagonally, if it is desired to give greater stability to the structure. If these are laid diagonally, those of each succeeding floor should be at right angles with those on the next floor below, thus forming very efficient bracing in two directions.

The roof timbers may be 10 x 12 inches, and have a pitch of one-half inch to a foot. The roof is composed of 3-inch planks, the same as the floors, and covered with three thicknesses of roofing felt, and over this with tar and gravel, in the usual manner. If preferred, heavy roofing paper may be put on, then mopped with tar and heavy roofing tin used. The roofing paper under the tin will prevent the difficulty of condensation.

The rafters should be fastened at the outer ends by vertical bolts anchored in the walls, and by $\frac{3}{4}$-inch iron dogs where they meet in the center. Ordinarily it is not necessary to have a supporting post in the center where they are joined together.

There need be no gutters on this style of roof, as a sloping concrete strip 2 feet wide laid around the building, and closely against the foundation wall, will answer the purpose of carrying off the water from the roof as well as protecting the wall from saturation by surface water. However, gutters may be added, and in some later examples are so arranged as to hold the water from flowing over the eaves and pass it along to conductor pipes running down inside the building so as to be safe from the liability of freezing up in winter. These gutters are more readily applied to roofs covered with tin than to gravel roofs, owing to the difficulty of making a water-tight joint between gravel and tin and, also, the liability of the tar on a gravel roof melting and running down the sides of the gutter and into the conductor pipes, if the sides of the gutter are formed of tar and gravel, the same as the roof.

For buildings of over two stories it is advisable to have gutters, as it is also where the building forms one side of a much used yard or driveway, where the dripping water, liable to be blown about by the wind, would make it very objectionable.

The windows will be constructed in the manner described for windows generally, in the chapter on lighting, to which the reader is referred. It will be understood that the figures herein given for walls and beams are nominal, and that in each individual case they must be of such dimensions as are called for by the loads and strains they will have to sustain, the vibration to which they will be subjected, and the height of the building.

CHAPTER VI

SLOW-BURNING CONSTRUCTION OF WOOD ONLY

A practical form of construction. Should not be over four stories. Two stories preferable for a machine shop. Foundation walls. Supporting posts. Strengthening knees. Lengths of bays. Side walls. Vertical planking. Steel shingles. Cold water paints. Ground floor timbers. Floor planks. Air spaces. Floor laid directly on coal-tar concrete. Three methods of floor construction. Improved form. Another plan. Second-floor construction. Roof construction. Roof planking. Truss bracing the framework. Strength of this form of construction.

It is entirely feasible to construct a practical form of machine shop or factory building entirely of wood, and on account of the relative cheapness of the materials it will be necessarily more economical to do so than to build it of brick and wood combined.

It is not usual, however, to build in this form over four stories in height, and it is perhaps better to confine the height to two stories, when it is to be used as a machine shop, or for manufacturing when machinery is to be used, unless it is of a light variety.

Fig. 14 is an isometrical perspective of this form of construction, shown of two stories.

Foundation walls are built on all four sides, the same as if brick walls are to be erected. Piers are built to support the central posts, and all posts and sills rest upon cast iron plates bedded in cement mortar on the walls and piers.

All posts extend from the walls or piers to the rafters. The floor timbers of the second floor rest upon wooden knees bolted to the posts. If preferred, these knees may be made of cast iron, but the difference in the cost of the two will not be great, and there will be the liability of the cast iron to crack under very heavy and sudden strains unless carefully designed for the purpose. In case they are used, all component parts or members, such as the resting plates, strengthening ribs, etc., should be of nearly equal thickness, in order to prevent undue strain on the metal in cooling after they are cast. Ribs, say three quarters of an inch to one inch square, according to size of the timber to be supported, may be formed on them and these let into grooves cut in the timbers, which will materially assist the bolts in holding them in proper position, and in resisting strains.

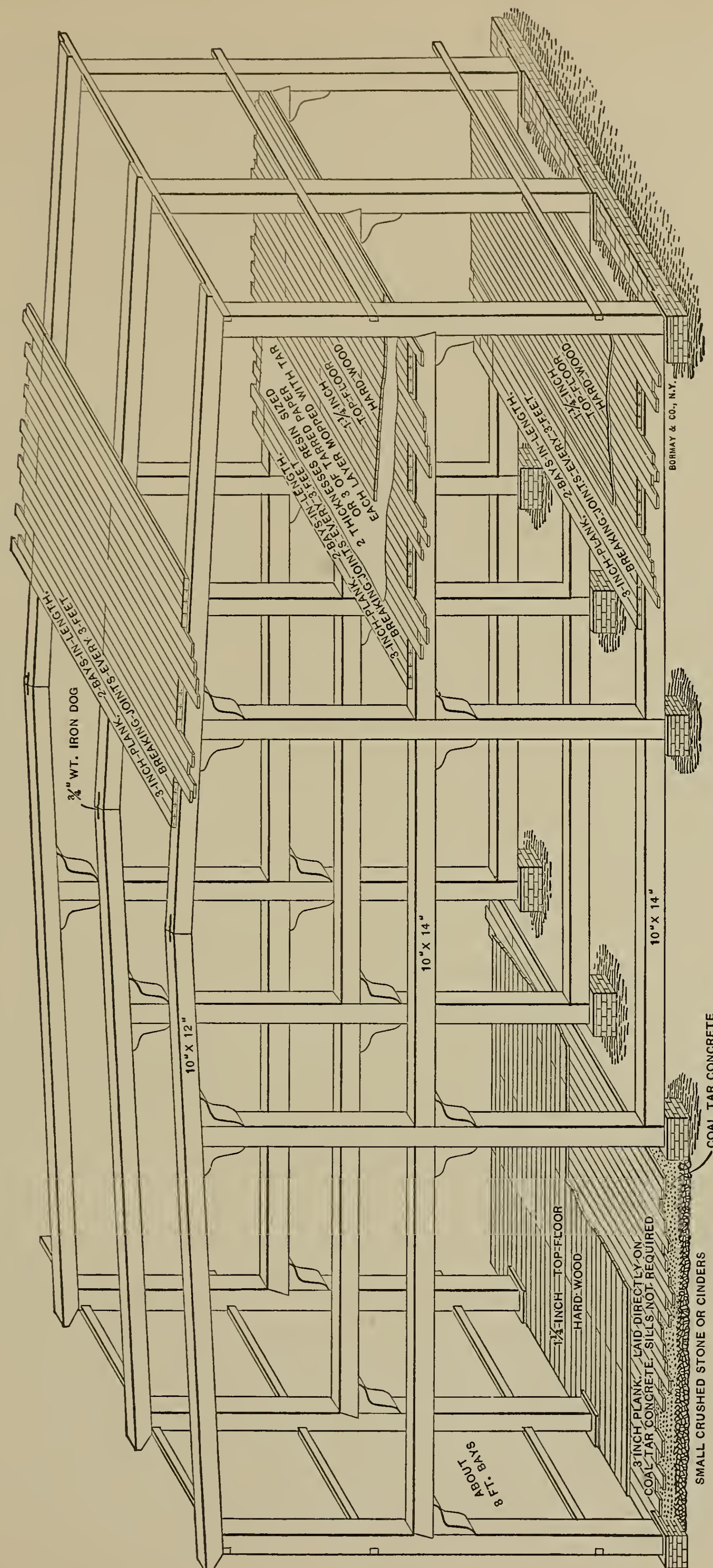


Fig. 14. — Factory Building of Slow-Burning Construction, of Wood only.

The bays of this form of building are built about 8 feet centers, and the transverse span of the floor timbers should be about 20 feet, never to exceed 25 feet.

The sides of the building may be of 2½-inch, or 3-inch planks, planed on the inside, tongued and grooved, or better, with a groove in each edge and separate splines put in, and spiked on horizontally, the window frames sustaining the ends of the planks reaching them. The planks should be at least two bays (16 feet) in length, and nominally break joints every three feet. As the spaces above and below the windows are the only places where the planking is horizontally continuous, it will be better to break joints every two planks.

If preferred, the planks may be put on vertically, for which purpose horizontal spiking strips may be let into the posts, or spiked on their surface, at the tops and bottoms of the windows.

A very strong and rigid structure may be constructed by applying the planks in a diagonal position, thus bracing the framework in a most effectual manner. The waste of materials will be somewhat increased, and the labor cost will be considerably higher.

Outside of this planking may be applied corrugated iron, sheet steel shingles (so-called), or sheet steel stamped to represent clapboards or stone work. A large variety of this material is now made in artistic forms, which is easily applied, attractive in appearance, very durable when kept painted, and nearly impassable to any ordinary fire.

The timber work showing inside, as well as the under side of the second-floor planks, and the roof planks, should be planed and may then be kalsomined or covered with any of the so-called "cold water paints," which may be of any desired tint, neat appearance, and sufficiently porous to permit the timber to season nearly as well as if it were not covered at all.

The ground floor may be laid upon floor timbers, as shown at the right of the engraving, and should consist of 3-inch planks, about 6 inches wide, grooved on each edge, and have separate splines fitted in. They should be two bays (16 feet) in length, and break joints every three feet. Upon these should be laid a top flooring of 1¼-inch hard wood, running the same direction as the 3-inch planks. These planks may be taken up and replaced at any time when they become worn and unfit for further use, without disturbing the main flooring.

To preserve this floor from decay, an air space, at least the thickness of the floor timbers, and twice that is better, should be left under it and be ventilated by small grated openings in the foundation walls.

At the left of the engraving is shown a floor laid directly upon coal-tar concrete. There are three methods of putting down this kind of a floor. The first style is to lay down a foundation or bed of small crushed stone or

cinders to the depth of six inches, for ordinary purposes. Upon this is laid two inches of coal-tar concrete, or of sand mixed with hot coal-tar, and directly upon this is laid 3-inch planks, not tongued or grooved, and over them, and at right angles to them, a top floor of 1¼-inch hard wood planks. These being spiked together form a solid and rigid mass supported by the concrete.

This form may be much improved upon by laying 3 x 4 inch sleepers, which have previously been mopped with hot tar, on the crushed stone, or cinder bed, leveling them up and then filling in the spaces flush with the top of the sleepers with hot tar concrete, then spiking down a main floor of 2-inch planks, not matched, and over this, at right angles to it, nailing down a top floor of 1¼-inch hard wood planks.

Still another plan is to lay down the crushed stone or cinders as before, drive stakes four feet apart each way, the tops level with what is to be the under side of the floor. To these spike nailing strips, say of 2 x 4 inch scantling, set edgewise, previously tarred on the bottom, and fill up the spaces with coal-tar concrete as before, and spike down 2-inch planks. This makes a cheap floor and is sufficiently solid and durable for many cases. If it is to be subjected to hard usage, it will be advisable to cover it with a top floor which can be readily renewed when worn out.

The second floor is built like that in the preceding chapter, that is, 3-inch grooved planks, with separate splines, two thicknesses of rosin-sized paper, mopped with hot tar, and a top floor of hard wood 1¼ inches thick. The 3-inch planks are at least two bays (16 feet) in length and break joints every three feet.

The roof is built with the rafters supported on the side and center posts, fastened at the center with ¾-inch iron dogs and bolted to the side posts and to the knees of the center posts. The rafters have a pitch of one half inch per foot, and are covered with 3-inch planks, grooved on both edges, joined by separate splines, two bays (16 feet) in length and breaking joints every three feet. The roof planks may be covered with roofing paper mopped with tar, and over this thick roofing tin, or with two or three thicknesses of roofing felt, and then tar and gravel, in the usual manner.

If it is desirable to erect a frame that shall be entirely self-sustaining, before any planking is put on, it can be done by letting into the outer posts spiking strips in a diagonal position, forming truss-like braces. These will be under the windows on the first floor, and between the first and second-floor windows. In this manner the frame may be rendered very rigid.

While this construction is simple and apparently not heavy, such a building will sustain great weights in proportion to the amount of materials used in their construction, and will successfully withstand shocks, strains, and vibration that would seriously injure structures of seemingly much greater strength.

CHAPTER VII

ONE-STORY MACHINE SHOP OF BRICK AND WOOD

Their economical construction. Economy of operation. The walls. Central supporting posts. Traveling crane supports. Foundation piers. Floor construction. Floor foundations. Roof construction. No gutters usually necessary. Form of gutters, if used. Window construction in monitor roof. Kind of glass preferable. Side window construction. Window frames. A practical, efficient, and economical building.

FOR machine shops on level land where little grading or preliminary preparation is necessary, and when the stock, materials, and machinery are all comparatively heavy, one-story shops may be very economically built, according to the plan represented in Fig. 15.

Such a building is not only economical to construct, but also to operate, in that stock and material is easily and cheaply moved from place to place; a traveling crane space is provided; it can be built of any length, and nearly any convenient width; it may be well lighted, no matter in what direction it faces; the form of the timber work renders the hanging of shafting and the putting up of countershafts convenient and economical; it is easy to heat and may be readily ventilated, and the heavy plank roof is free from the trouble of condensation in cold weather.

The walls are of brick, 16 inches thick, and the divisions into window spaces or bays are 10 feet. No pilasters are necessary on a wall of this height, unless very heavy machinery or material is to be employed.

The piers between the windows furnish support for the roof timbers, which are 8 x 16 inches, and placed 10 feet centers, and have a pitch of one half inch to the foot.

The central posts are 10 x 10 inches, and in addition to furnishing support for the inner ends of the roof timbers, they also support the monitor roof structure, whose rafters are cut to the necessary form to give the roof a pitch of one half inch to the foot. To insure rigidity, and to resist wind-pressure, they are braced as shown. If the building is to be for very heavy work the central posts should be 12 x 12 inches.

Along the insides of the central space is run a timber support for the track of the traveling crane. These timbers are bolted to the posts and in

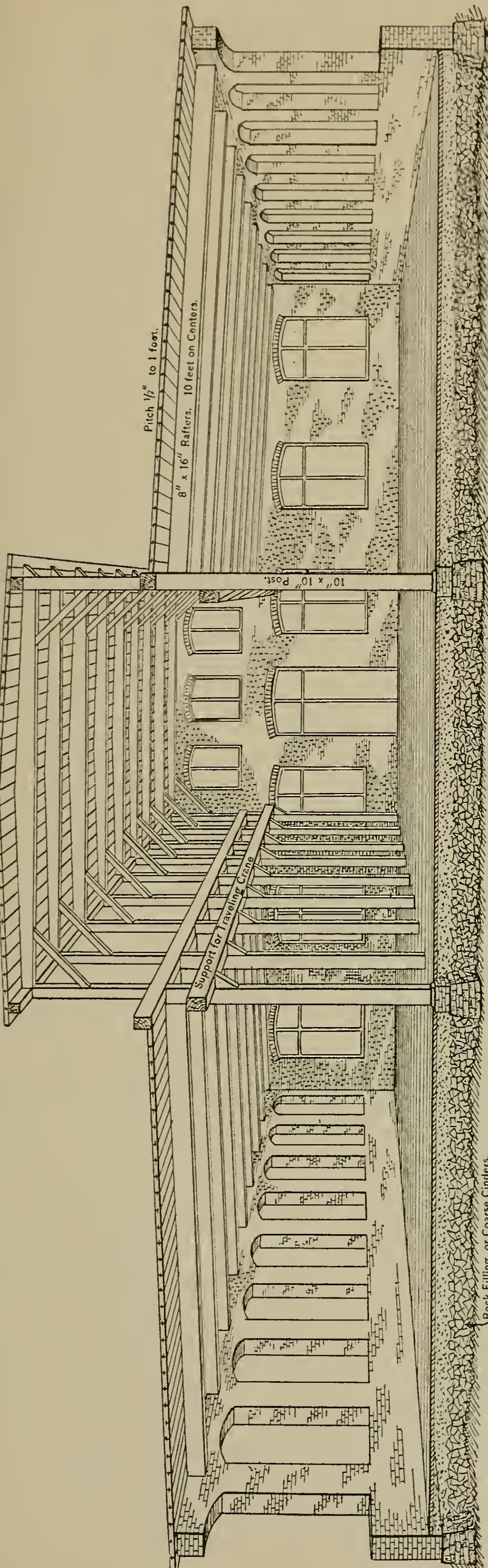


Fig. 15. — Machine Shop of one story, Slow-Burning Construction, of Brick and Wood.

addition are supported by brackets, also bolted to the posts. These brackets may be of either hard wood or of cast iron. If the latter, they may have a rib let into the post, for additional strength. If the traveling crane is to handle very heavy loads it will be necessary to support the horizontal timber by auxiliary posts bolted to the main posts and the horizontal timber resting upon their upper ends.

The foundation piers on which the central posts rest should be deep and have a broad base, as they will probably be called upon to sustain much greater weights than the foundation for the side walls, particularly if the shop is designed for heavy work.

The floors should have ample foundation support, and should be constructed by putting down from six to ten inches of broken stone or cinders, well rammed down. Upon this bed floor timbers 4 x 6 inches may be laid four feet apart, first applying hot tar to their under sides. These having been carefully leveled up, the spaces and all interstices under them should be carefully filled with a concrete of sand of very clean, fine gravel, mixed with hot coal-tar. When this has thoroughly set and hardened, a floor of 3-inch planks may be spiked down. Over this, and at right angles

with it, should be laid a 1½-inch hard wood floor, which may be readily renewed when it is worn out. The floor timbers and the top floor should run lengthwise of the building and the 3-inch planks crosswise.

A concrete floor may be laid in the central portion, and the above method of plank floor be laid in the side portions.

Where the machinery to be used in the side portions of the building is of moderate weight, and the stock to be handled therein is not particularly heavy, the foundations for the floor need not be of such a substantial character as that described. Probably four or six inches of broken stone or cinders will be quite sufficient for the purpose. The floor planks, too, may be lighter. say 2-inch for the main floor and 1¼ for the top floor, and the floor timbers 4 x 4 inches.

It is assumed that in all cases the ground has been properly prepared and leveled up before the crushed stone or cinder bed is put down. For this very necessary preparation the reader is referred to the chapter on foundations.

By lessening the depth of the foundation and reducing the thickness of the planks, the expense is considerably reduced and, under the conditions mentioned, the efficiency of the building maintained.

The roof is composed of 3-inch planks, 6 inches wide, with a groove in each edge, and joined by a separate spline, and should be 20 feet long, so as to reach over two spaces between rafters. They should break joints every six planks. Upon these planks is laid either heavy roofing paper, mopped with tar, and then thick roofing tin, or three thicknesses of roofing felt, then coated with hot tar and covered with clean gravel in the usual manner.

No gutters are necessary, the water dripping from the eaves being caught by a strip of concrete 2 feet wide all around the foundation and inclining about 2 inches. This not only takes the water from the roof, but protects the foundation from surface water.

When the building is so located, from its position with reference to other buildings, or to a yard where work is being carried on, that it is not advisable to run roof water off on the ground, gutters may be formed of tin, or better, of galvanized iron, with proper connecting pipes to carry off the water. If the gutters are formed of the roofing felt, tar, and gravel, they will have to be of rather flat sides in order to prevent the tar from running down the conductor pipes when melted by the hot summer weather.

The windows of the monitor roof may be set singly, say 3½ feet wide, between the uprights supporting the roof, or they may be made with double sashes in one frame, giving two windows, 3 feet wide each. The top sash should be hung on pivots so as to be opened for ventilation. Ribbed glass will be preferable for these windows, to avoid the glaring light which plain glass would admit upon the erecting floor under the traveling crane.

The side windows may be of two or three sashes, preferably three, the upper sash pivoted and the other two sliding sashes. Ribbed glass should be used in all but the bottom sash, which will very much improve the cheerfulness of the shop by being of clear glass.

The side window frames may be made of the form shown in the back wall, the upper portion being hinged or pivoted for ventilation, and the lower portion divided into two sashes on each side; but the dark shadow cast by the center upright in a double window frame is avoided if we make the window wider and employ a single sash in width.

As will be readily seen, the entire building is designed and constructed with a view of producing a practical, efficient, and commodious structure and one that will be, at the same time, as well adapted to the special uses and purposes for which it is intended as many buildings which are much more elaborate and costly; and still to so construct it as to make it a typical example of slow-burning construction.

CHAPTER VIII

SAW-TOOTH CONSTRUCTION OF ROOFS

The newest form of shop roof. Appearance and symmetry sacrificed to utility. Perfect illumination. Broad buildings may be properly lighted. Preferable for large areas. Economy of heating buildings with this form of roof. Roof angles. Roof construction. Steel and wood. Example of this form of building. Side walls. A high central space. Materials used in the construction. General design. Traveling cranes. Auxiliary cranes. Distribution of power for traveling cranes. The electric system. Roof trusses of steel. Roof trusses of wood. Ventilating windows. Ribbed glass. Roof planking on steel trusses. Roof planking on wood trusses. Gutters and valleys. Conductor pipes. Economical construction.

One of the most important advances in the design of machine shops and manufacturing buildings of the past few years is what is generally known as the "saw-tooth" construction of roofs.

Appearance, uniformity, and symmetry, are sacrificed to the idea of practical usefulness; the principal object being to secure as perfect and equal illumination as possible over the entire floor, whether the buildings are large or small.

Heretofore this has been one of the difficulties not entirely overcome, and in consequence of this drawback it has not been possible to construct buildings beyond a certain width, owing, in this respect, to the dark zone along the center. With this new method of lighting we may practically make them as wide as we please and be assured that the central portion is, for all practical purposes, as well lighted as near the side walls. This is a great advantage in buildings in which large and heavy machinery is to be constructed, as this class of work may be much more economically built in shops having but one story; and as the earth furnishes the best foundation for a floor for heavy weights, this is desirable on that account. By this observation it is not meant, of course, that floors are to be laid directly upon the ground.

Again, for this class of work a large area is needed, and to construct comparatively narrow buildings in order that we may have the center of the room well lighted, is expensive as well as inconvenient in moving large machines, or in working around them.

By this method of construction the buildings may be very broad and

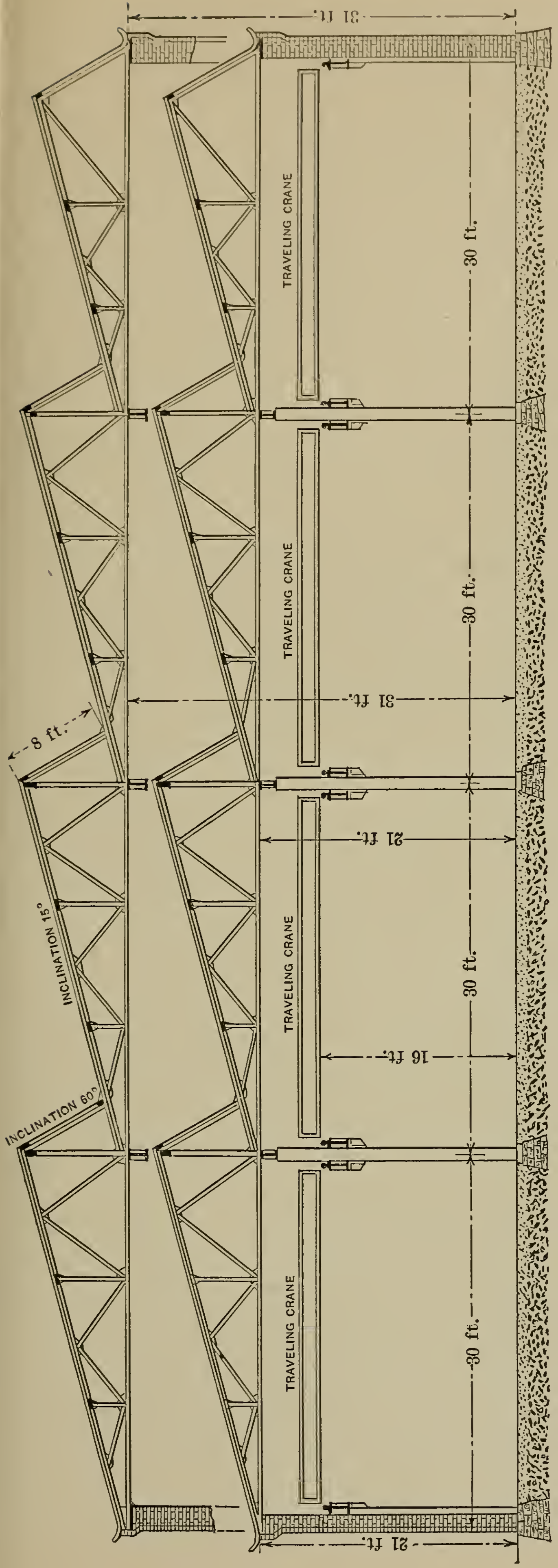


FIG. 16.—Longitudinal Section of Machine Shop with Saw-tooth Roof of Steel Construction.

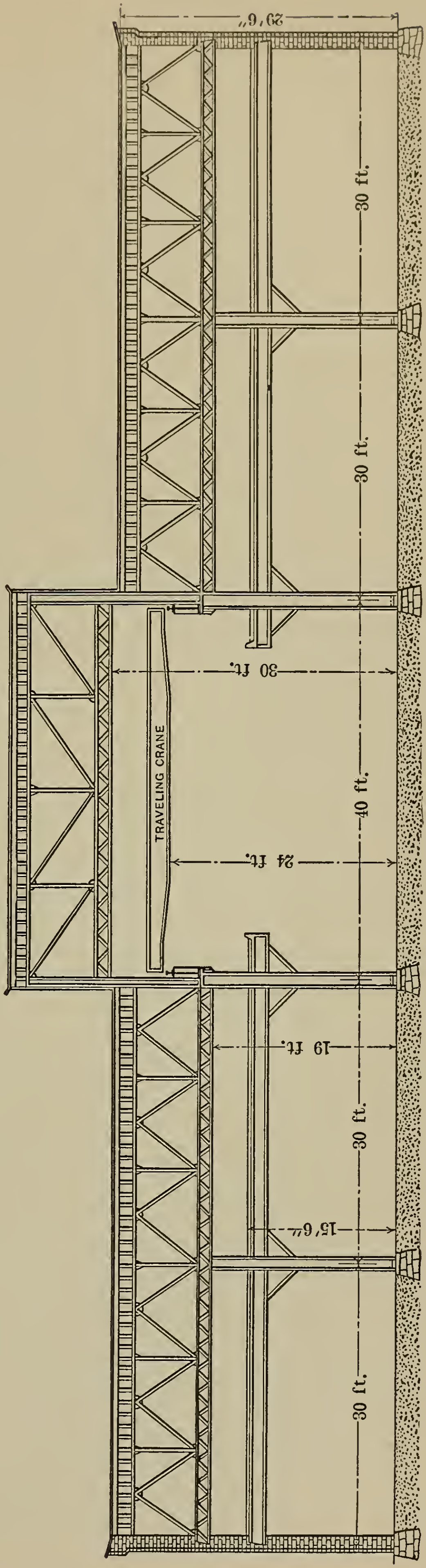


FIG. 17.—Transverse Section of Machine Shop with Saw-tooth Roof of Steel Construction.

low and consequently easy to heat, and, as has been said, with good illumination over the entire floor.

The essential feature of the saw-tooth construction consists in forming the roof in broken sections, the roof proper having an inclination of about fifteen degrees, and the glazed portions an inclination of about sixty degrees.

Fig. 16 is a longitudinal section and Fig. 17 a transverse or cross-section of a machine shop with this type of roof, the construction being of steel. Fig. 18 and Fig. 19 represent a similar roof with wood used in its construction instead of steel. In Fig. 20 is given a perspective view of the machine shop when finished, showing the general arrangement of the high central portion and the lower portions at each side.

The side walls are built in the usual manner, with pilasters to strengthen them. They are pierced for windows on the same general plan as in the previously described buildings.

The plan of the building is the well-known one wherein a high central space is provided for an erecting floor, over which a heavy traveling crane is mounted, covering every part of this floor. The sides of this building, where it reaches above the side portions, may be planked up and covered with tarred paper and then tin, or, still better, with the specially stamped sheet steel. Corrugated steel or iron is sometimes used. Either of these plans will answer the purpose.

The side portions are built considerably lower as the same height is not here necessary or desirable. These portions are provided with smaller traveling cranes, running upon I-beams or girders which project into the central space, as shown in Fig. 17, so that these cranes are capable of depositing their loads within the reach of, and under, the main crane.

If much heavy work is to be done, each of the bays, on both sides of the central portion, is supplied with one of these cranes, as shown in Fig. 16 and Fig. 17. By this means any load may be quickly and conveniently transferred from any one point, within any one of the bays to any point within any other bay, or to any point in the central erecting space, by the combined use of the main and secondary cranes.

In many cases it will be necessary to have these secondary cranes on one side only of the central space, the other side portion being reserved for machines and work of a lighter description. So, also, it may not be necessary to equip all the bays on one side, even, with secondary cranes, while it may be necessary, and very convenient, to so equip several bays in this way. The nature of the work may be such that it will be convenient to equip several bays on each side and at one end with secondary cranes so as to arrange all the heavy work across the end of the shop instead of along the side.

As a matter of course, if traveling cranes are to be used over the bays

we must provide such a system of driving power as not to interfere with them. Shafting may be used near the side walls for driving machines under it or near to it, but the main dependence will have to be the electric system, which, with separate motors for each machine, or one motor for a group of machines located closely together, seems to be the favorite method of driving.

Fig. 16 shows the most approved form of truss for supporting this type of roof, and Fig. 17 gives the form of girders used to support the ridges of the roof where the glazed portion joins the roof proper. This construction is of light structural steel and no more members are used than is absolutely necessary, hence the entrance of light is very slightly interrupted and still there is sufficient strength for all practical purposes.

The glazing of the light portions should receive much attention, in order to avoid leakages, as this is always one of the drawbacks of any kind of inclined windows.

For purposes of ventilation the sashes may be hinged at the top and opened by any convenient means. A simple device is to run a light shaft along inside the building and near the bottoms of the sashes, and fix to it cast iron arms, in the form of cranks, for each sash. From these arms connecting rods run to the sashes. This shaft may be operated by fixing to it a grooved pulley, over which a small rope runs, and reaches down near the floor, from which it may be operated. Levers standing in opposite direction on this shaft, and having a cord attached to each end, may be used for the same purpose. These shafts ought not to be over 50 feet in length, operated by one set of ropes. Pieces of shafting 15 or 20 feet long can be easily coupled together. The plainest possible construction is sufficient for all practical purposes.

Ribbed glass should be used in these sashes as it prevents the glaring effect of direct and unimpeded sunlight, and diffuses a soft and agreeable light over the whole area to be lighted.

In Fig. 18 is shown a longitudinal section, and in Fig. 19 a cross-section, of this same style of roof, but in this case it is constructed principally of wood instead of steel. The form of the inclined truss, and the method of securing the timbers by bolts is clearly shown. Wall plates of the form shown should be used, as well as proper resting plates on the tops of the central posts, or columns, so constructed as to not only properly support the truss for holding the window frames and sashes, but also to furnish a proper abutment for the lower end of the rafter braces.

The roof timbers should be secured to the walls and to the posts by anchor bolts, to prevent the roof from being lifted by high winds.

In putting on the roof planking for this type of roof different methods

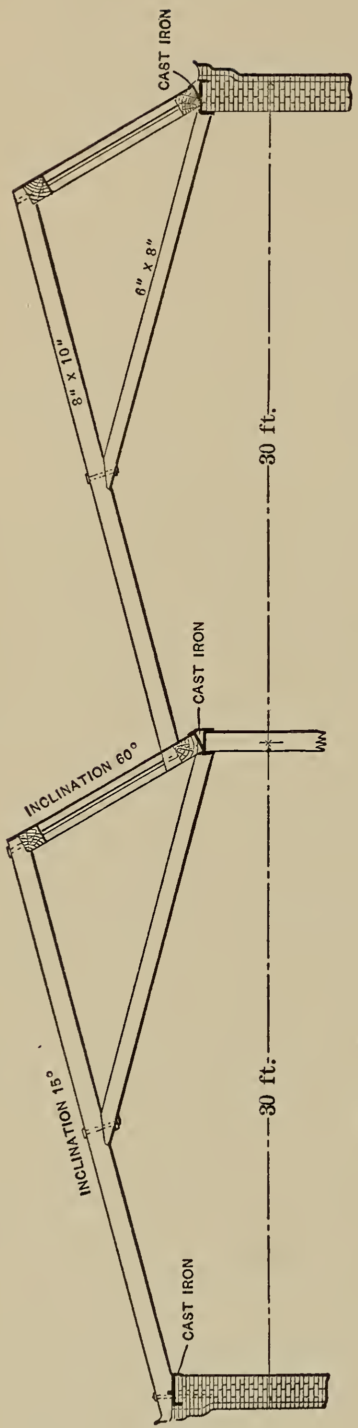


Fig. 18. — Longitudinal Section of Saw-tooth Roof of Wood Construction.

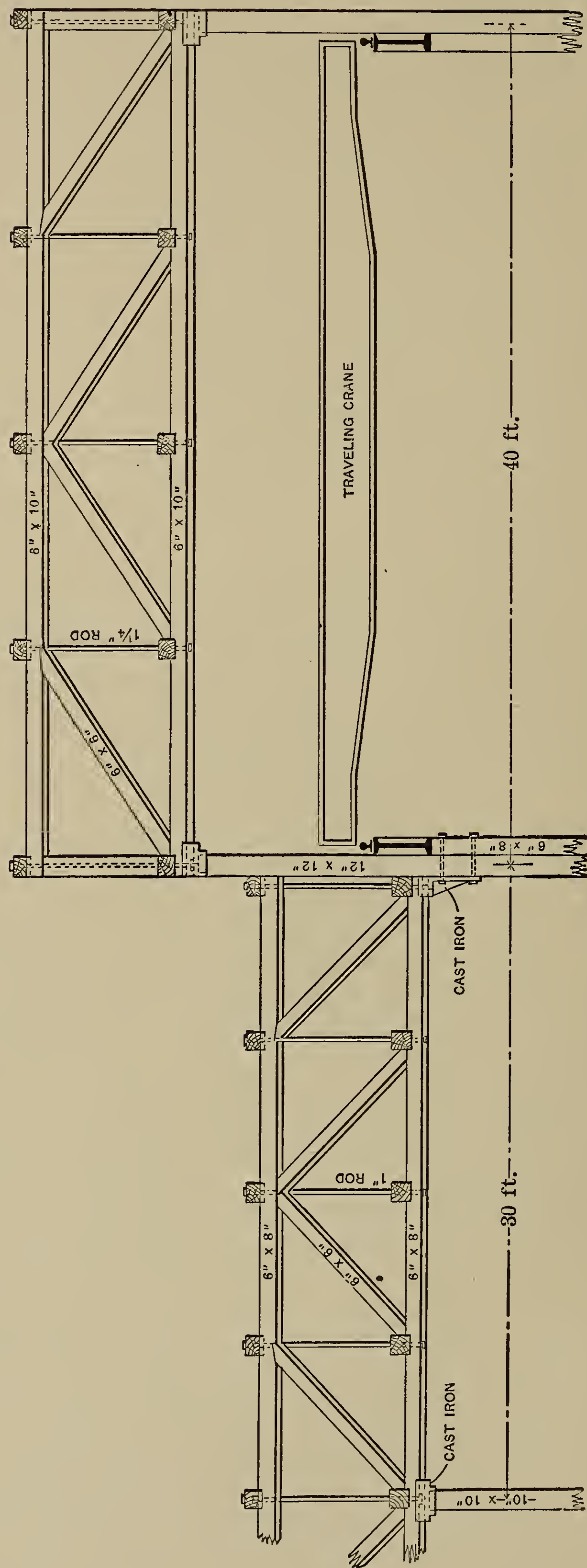


Fig. 19. — Transverse Section of Saw-tooth Roof of Wood Construction.

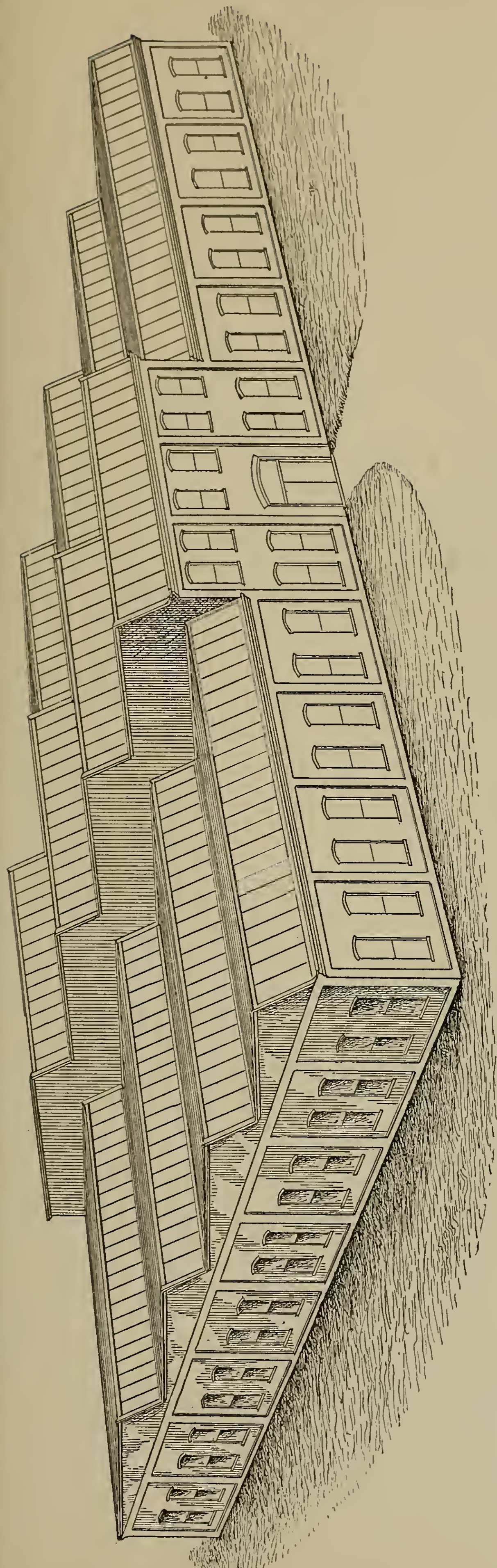


Fig. 20. — Perspective View of Machine Shop with Saw-tooth Roof.

must be adopted for the steel construction from that used for wood trusses and roof timbers.

In the case of the steel trusses, the supporting bars are shown in solid section in the longitudinal section, Fig. 16, and to these the planks may be secured by bolts, or lag screws, if steel supports are used, or by spikes, if these supports are of wood. In either case the planks will run in the direction of the pitch of the roof.

If the wood construction is used, the rafters will be not over 10 feet centers, and the planks long enough to reach at least two spaces, or twenty feet, and are spiked directly to the rafters, consequently they will run at right angles to them. The planks should be 3 inches thick and 6 inches wide and be grooved in both edges, and have separate splines put in to connect them.

In case of either steel or wood construction, the roof planks should be covered with good rosin-sized roofing paper, mopped with hot tar, and upon this a heavy quality of roofing tin, or some form of the modern sheet steel roofing. All sheet metal should be painted on the under side before it is laid.

The gutters or valleys of these roofs should be the subject of careful attention. They need not be of sharp pitch, as a quarter of an inch to the foot will be

sufficient. Conductor pipes at each valley should carry off the water. In the case of the shop shown in perspective in Fig. 20, the valleys on the high central portion should incline each way from the center and from each side, conductor pipes carrying the water to the valleys in the lower part of the building, and from thence it flows to the conductor pipes at the sides.

Either of the methods above described for constructing the roof will be found economical to build and well adapted to the purposes for which they are to be used.

CHAPTER IX

DESIGN AND CONSTRUCTION OF CHIMNEY, OR STACK

Peculiarities of chimney design. Brick construction. Foundations. The various types of chimneys compared. Steel chimneys. The proportions of the chimney. Height of chimney. Its dimensions to suit certain boiler capacity. Methods of calculation. Limits to the heights of single wall chimneys. Vertical and cross-sections. The outer walls. Octagonal versus square forms of construction. Relative numbers of bricks used. The chimney base and foundation. Quality of mortar. The central core. Care in construction. Form of central flue. The cap. Provisions for reaching the top. Lightning rods. The chimney of strength and the chimney of expediency.

Thus far our methods of construction and the necessary materials for them have been such as are encountered daily by the architect and the builder. We now come to the erection of the chimney or stack, which has many peculiarities and restrictions on its design and construction, resulting from its narrow foundation, great height, and the necessity of its resisting not only the high-wind pressures and great changes in temperature at different seasons, but also the great difference of temperature on the inside and on the outside. It seems necessary, therefore, to treat this subject of chimney construction in a separate chapter wherein we will consider the respective merits of and the objections to chimneys of the more common forms and materials.

Regarding the chimney built of brick, the principal objections would appear to be its first cost, which is considerable, and the fact that owing to its narrow base and great height very firm and solid foundations must be prepared. This, of course, becomes more difficult and expensive where the ground is soft and excavations must be made at great depth, or where piles have to be driven to build the foundation upon.

At the present time many sheet iron or steel chimneys are erected, and it is the prevailing idea that they are the more economical. About the only advantage they seem to possess, however, is that owing to their comparatively light weight they may be erected on superstructures upon which a brick chimney could not. Then, too, their first cost is much less than for a brick chimney of equal capacity.

Some of their disadvantages are, that they are very liable to rust at the seams and rivets, owing to the impossibility of keeping these points properly protected from water. Therefore they are comparatively short lived.

Since the above paragraph was written the author saw one of these steel chimneys which had been built by a most reliable firm, erected with a great deal of care, painted with the best materials to be had, that in a little over a year became a total wreck, owing to the rusting of the material around the joints and rivets. A new stack had to be erected. The combined cost of the two would have built a good and substantial brick chimney that would have endured for many years.

Again, in the effort to protect the metal they must be frequently painted, or coated with some of the numerous "cure-all" paints, "warranted to protect them perfectly inside and out"; and the use of *any* protective covering is a continual expense for maintenance to which the brick chimney is not subject.

The conclusion, therefore, must be that, if the life of the chimney is of less consideration than its first cost, we would adopt that constructed of sheet iron or steel; but if we regard permanency and the ultimate outlay, both for construction and maintenance and all the advantages derived, brick is evidently the material to be chosen.

The height of the chimney will depend somewhat upon surrounding hills, high buildings, and similar obstructions to the free course of the wind, but should never be less than the diameter of the internal flue multiplied by twenty. The diameter of the internal flue will depend on the aggregate areas of the smoke flues or "up-takes" leading from the boilers, and these necessarily depend upon the grate surface, allowing about 4.5 square feet per horse-power.

There are many methods of calculating the diameter of chimney flues, some of which are very complex and depend upon many assumed conditions at each step, which ofttimes have hardly more practical value than guesses. Others assume to calculate the volume of gases, the speed of their flow, the area of grate openings, etc., all of which might be changed with each sample of coal, or according to the condition of the weather.

Practical engineers will probably favor the following simple method, even with its arbitrary assumptions, and will be quite successful in the practical application of it as it is the result of much actual experience. The horse-power being given — say in this case 470 — and allowing 4.5 square feet of grate surface per horse-power, we have 104.4. At 5 pounds of coal per horse-power, which is quite liberal, we will burn 2,350 pounds of coal per hour. Our chimney is 100 feet high. We divide the pounds of coal burned per hour by the square root of the height multiplied by 12 ($10 \times 12 = 120$) and we have 19.58 as the area of the chimney flue, in square feet. Divide this by .7854 and extract the square root and we have the diameter, slightly less than 5 feet.

Having the diameter of flue and height given we may by inverse methods

obtain the horse-power, grate surface, etc. In making these calculations we should be sure to get capacity enough; for if the chimney is a little too large no harm is done, while if a little too small a serious expense is incurred for a supplementary one.

All chimneys over 75 feet high should be built with a central "core," or flue, preferably of circular form, surrounded by an outside casing sufficiently strong to properly support the inner core and to resist the pressure of the strongest winds.

The thickness of the walls of both the outer portion and the inner core should be sufficient to be very rigid near the ground and gradually thinner as the walls rise, the "breaks" being, of course, on the inside of the outer portion and the outside of the inner core. These breaks are usually four inches, or the width of a brick at each step.

The "batter," or inclination of the outside face of the main structure should be a quarter of an inch per foot. In our case we are supposed to require a chimney 100 feet high, with a circular flue 5 feet in diameter.

In the illustrations, Fig. 21 shows a vertical section through the center of the chimney and its foundation. It shows the thickness of walls, special form of central flue, retaining caps at the top, and special arrangements for increasing the draft. Fig. 22 is an elevation of the exterior, showing its general form and appearance when completed. Fig. 23 shows a horizontal section through the octagonal portion on the line *AA*, Fig. 21. Fig. 24 shows a horizontal section through the square base, on the line *BB*, Fig. 21. Fig. 25 illustrates, on an enlarged scale, the number of bricks necessary for a course, if the square form were to be continued to the top. Fig. 26 shows the economy of adopting the octagonal form, as saving material and labor, and offering considerably less surface to wind pressure from certain directions.

In the Figs. 25 and 26 the upper half shows the laying of a "header" course and the lower half the laying of a "straight" course. In these two sketches it will be seen that in a header course the octagonal form contains 52 bricks less than the square form; and in a straight course 32 bricks are saved. Assuming five courses per foot in height, and that in each foot we have one header course, we save by the octagonal form 180 bricks. This, of course, is less as we approach the top, but the average saving will be considerably over 100 bricks per foot, or over 8,000 for the whole work.

Actual experience shows that the extra labor cost of making the many corners is more than balanced by the smaller number of bricks laid in the octagonal form than in the square form. The appearance is much enhanced and the wind pressure is considerably diminished by getting rid of the projecting corners.

The base of the chimney is of square form, this being more convenient

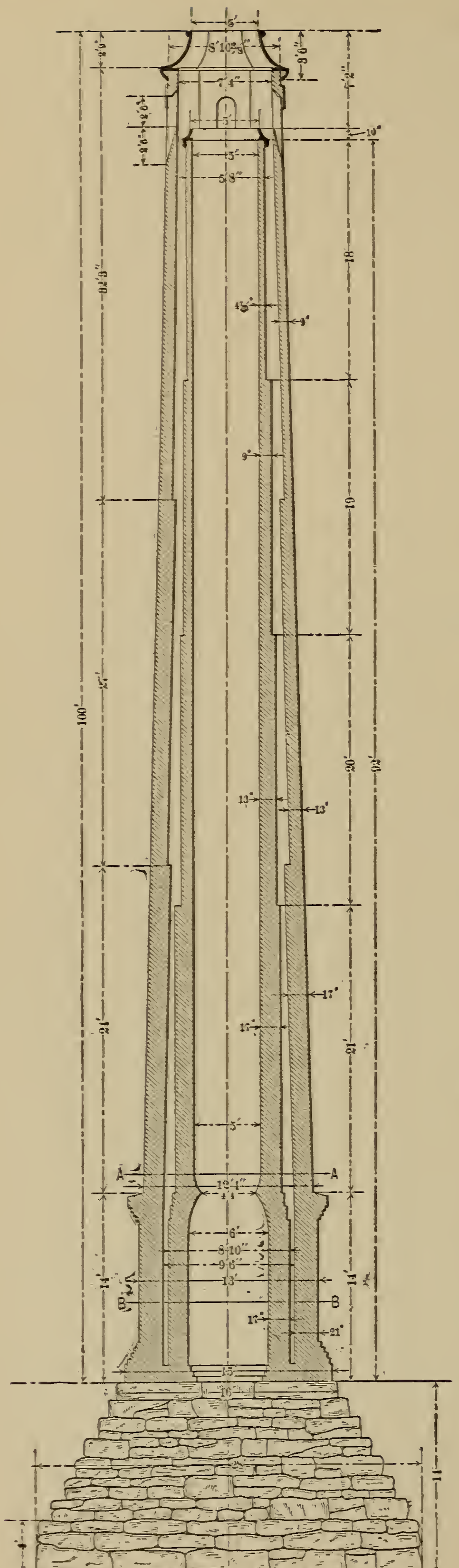


FIG. 21. — Vertical Section of Chimney and Foundation.

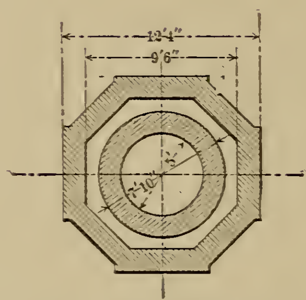


FIG. 23. — Horizontal Section through octagonal portion on line *AA*, Fig. 21.

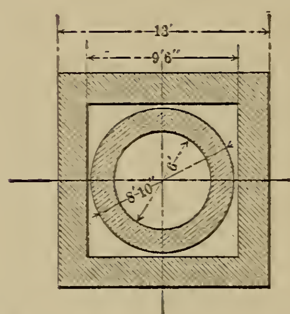


FIG. 24. — Horizontal Section through square base on line *BB*, Fig. 21.

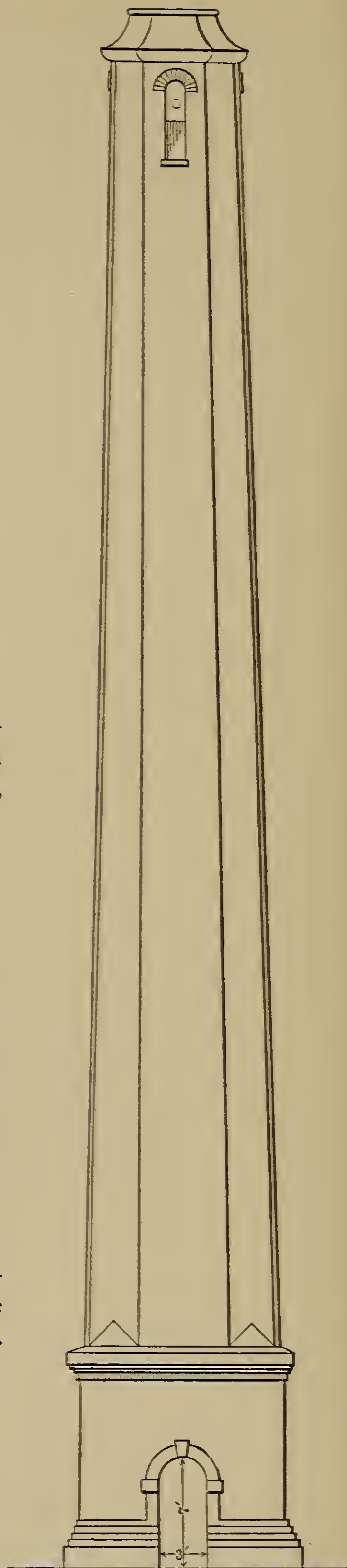


FIG. 22. — Elevation of the Completed Chimney.

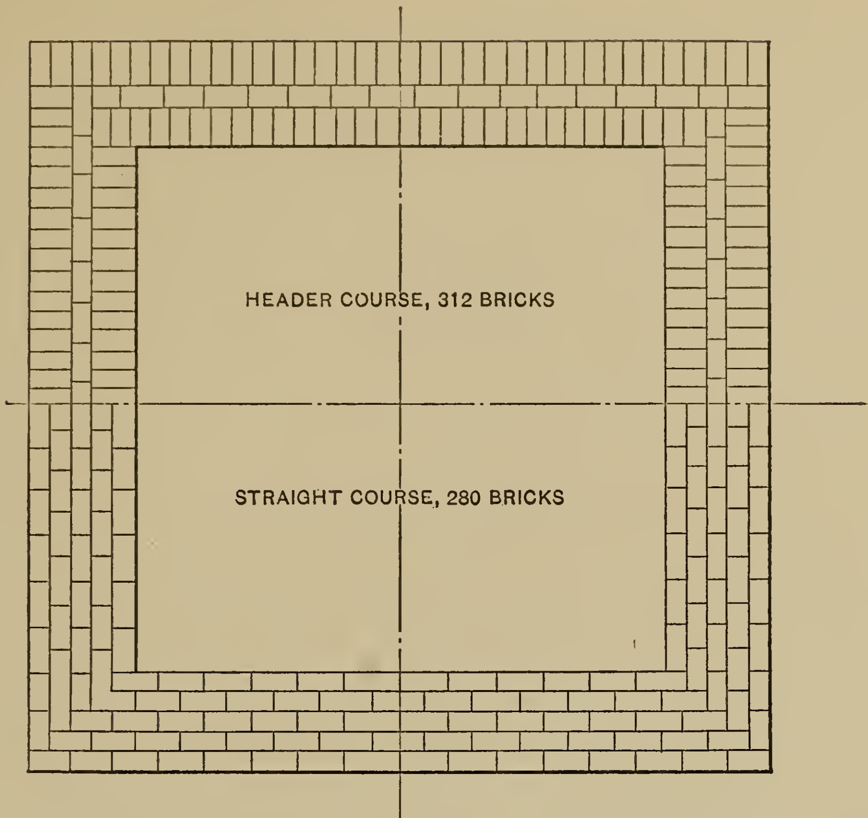


FIG. 25.—Horizontal Section, showing number of Bricks in the Square Form.

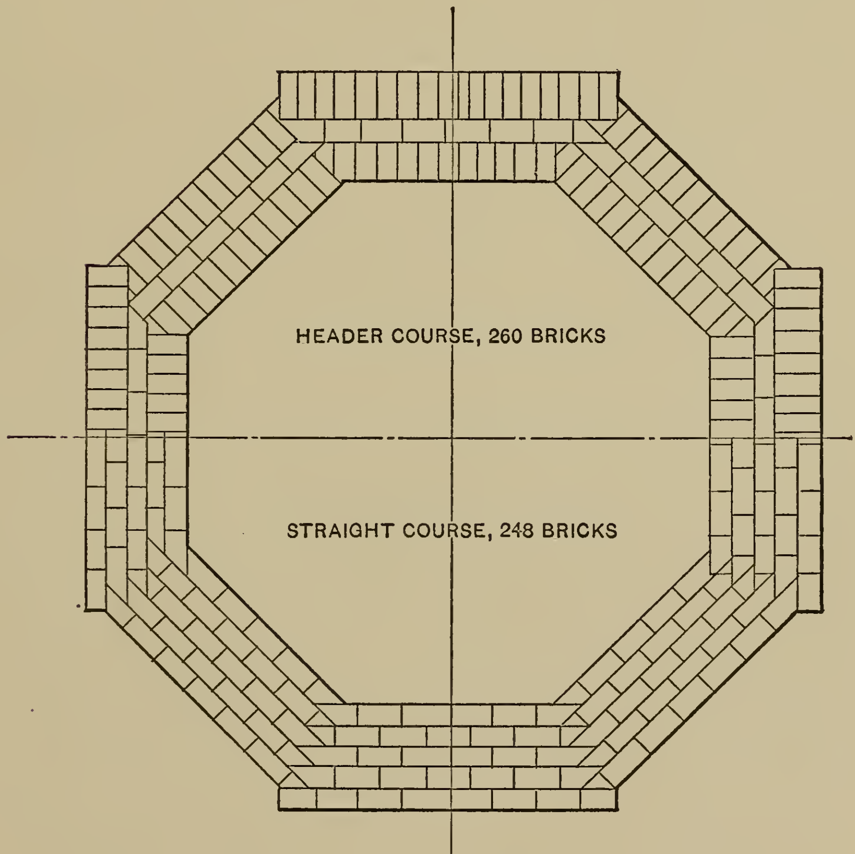


FIG. 26.—Horizontal Section, showing number of Bricks in the Octagonal Form.

for the introduction of the smoke flues or "up-takes" from the boilers, the placing of the ash doors and the general appearance.

The ash door is shown in Fig. 22. The opening should be arched, preferably of semicircular design, as affording the most strength to sustain the great weight of brickwork over it. It should be closed with a sheet iron door. The openings for smoke flues should also be strongly arched, similar to the ash doorways. From the square portion at the base, the main shaft of the chimney is of octagonal form, as indicated in Fig. 24.

For foundations the earth should be excavated to perfectly hard ground, making a pit 28 feet square; that is, twice the depth of the foundation, assuming that in consequence of the condition of the ground it is necessary to excavate to a depth of 14 feet. In this pit should be a bed, 4 feet thick of large stones laid in strong cement mortar. Upon this should be courses about 18 inches thick and gradually drawn in at the top to 16 feet square.

By strong cement mortar we mean that containing two parts cement, one part of lime, and about three parts of clean, sharp sand. The amount of sand will vary considerably with its fineness, sharpness, and its freedom from dirt; the finer the sand the greater the quantity that must be used.

In erecting the central core and the outward supporting structure great care should be used to make all joints of uniform thickness, and to see that as the courses are laid on they are frequently leveled.

"Batter plumbs" should be used for the outside; that is, the board on which the plumb line is attached should have the batter or inclination by being made narrower at the bottom. For instance, a plumb board 4 feet long should be 6 inches wide at the top and 4 inches at the bottom (the batter being equal on both edges).

Another matter that must be scrupulously attended to is that of properly supporting the inner core. It will not do to lay bricks from wall to wall so as to tie them together, as the expansion and contraction of the inner core would soon ruin the structure.

The support is given by building up into the outer wall inwardly projecting bricks reaching half way across the space, and against these, others projecting outwardly from the inner core. These should be placed on all eight sides, in the same course, and at intervals of not over eight feet through the entire height.

The form and thickness of walls and the heights of the "breaks" are shown in Fig. 21. The central flue is formed after the model of the well-known student lamp and forms a very effective combustion chamber for escaping smoke. It is the form adopted by a prominent engineer who built a large number of chimneys of this design which have been in successful use for many years.

The smoke flues enter the chimney below the constricted portion of the inner flue. The top caps are of cast iron and may be made in sections and bolted together, as well for convenience in erecting as for economy of pattern making.

That on the inner core terminates 7 feet 2 inches below the top of the main cap. At four sides of the outer structure are openings, as shown in Fig. 21, the bottom of each opening being on a level with the top of the inner cap. By this means the current of air which always rises along any high wall is taken advantage of, as it passes up the side of the chimney, into these openings, and out the top of the chimney, and creates a partial vacuum over the top of the central flue, thus considerably increasing the draft.

Means should be provided for reaching the top of the chimney, as the iron caps will need painting, or lightning rods may have to be placed or repaired. Iron ladders up the side may be fastened to the wall, or a permanent block may be attached to the main cap and provided with a wire rope, for this purpose.

As a matter of safety from lightning it is well to provide lightning conductors. A round copper rod of not less than $\frac{5}{8}$-inch diameter, or one of equal area of cross-section, may be run up outside of the chimney, through heavy glass insulators, and terminate four feet above the main cap in four points, $\frac{5}{16}$-inch diameter or equivalent area. The lower end of the rod should go into *moist* earth and be attached to a cast iron plate 30 inches square and $\frac{3}{4}$-inch thick.

It is often the case that chimneys are erected that are much higher in proportion to their width than the example here shown, and in situations where the structure is well protected from the pressure of the wind, this may be safely done. But when erected in an exposed situation it will be well to consider, as of first importance, the factor of stability.

It will not be proper or fair, however, to confound the appearance of a chimney built in the substantial form herein described, with some of the smaller and more slender structures sometimes seen, which have no central core, either because their moderate height does not render it necessary, because the temperature of the gases is not so high as to endanger a chimney of single walls, or from considerations of economy.

The chimney here shown is in every way substantial and reliable, and from the dimensions and proportions given, chimneys of any required capacity, or to suit any condition of surroundings, may be successfully designed and constructed.

CHAPTER X

CONSTRUCTION OF FOUNDATIONS

The proper bed for a foundation. Care necessary in its preparation. Sounding. The various types of foundation. Timber support for heavy buildings on alluvial soil. Timber support for foundations. Piling support for foundations. Timber and concrete supports for foundations. Laying stone foundations. Mortar for foundation work. Foundations for machinery in general. Engine foundations. Planer foundation. Special foundation for testing lathes or other machines. Drop hammer foundations. Steam hammer foundations. Timber foundation for heavy machines on soft ground. Example in experience.

It is but quoting an old maxim to say that if we are to build a good house we must have a good foundation to build it on. And we may just as pertinently say that if we are to build a good and substantial foundation, we must have something solid to lay it upon.

Otherwise we shall be like the man who built his house upon the sands. The diversity of the ground, at the surface and down through the stratifications of material of various densities and strengths, from the solid nature of rock to the almost fluid condition of alluvial soil, must be considered. Each of these conditions requires special treatment according to its nature.

To properly secure a firm bed for the foundation of a building, we must either excavate down to firm and solid ground, technically called "hard pan," or we must by artificial means produce a substantial surface upon which to begin the masonry. It is quite impossible for the architect, the mason or the contracting builder to tell us by a superficial examination of the ground how deep we must go to reach solid ground, or "hard pan."

To some extent this may be ascertained by "sounding"; that is, by making small excavations at various points, to obtain the necessary information upon which to determine not only the depth to which the foundation must extend, but whether the nature of the ground renders such artificial support as piles necessary.

It may be found that at some points in the foundation of extensive buildings we need excavate only a few feet, while at others, very deeply; and still at other points the ground may be of such a yielding nature that piles must

be driven. Or we may find that the use of piles would be a much more economical method than very deep masonry.

But whatever the depth we may be obliged to go to, or the process by which we produce our bed for the foundation, all parts of it must be, not only firm and practically unyielding, but level. Hence, when we excavate to varying depths the earth must be "benched out," as it is called, as shown in Fig. 31.

Great care should be taken to have all parts of the bottom of the excavation of as equal density and resisting power as possible, that they may equally support the great weight of the wall to be built. This condition becomes all the more important as the walls of the building are higher and the consequent weights and strains correspondingly increased.

It is, of course, true that no ground can be found so absolutely solid as not to yield somewhat when the weight of the building is put upon it, and therefore we must not expect to wholly prevent a certain amount of settling; but we should use all possible care to have this settling as equal as possible over the whole area of the foundation.

Having ascertained the nature of the ground as far as possible, we may determine the kind or kinds of foundation necessary. If the ground is so soft and yielding that excavation to solid earth will have to be very deep, making a stone foundation excessively expensive, piles should be driven as deep down as possible — say two feet apart from center to center — and cut off level at the top, and be down low enough to remain always wet.

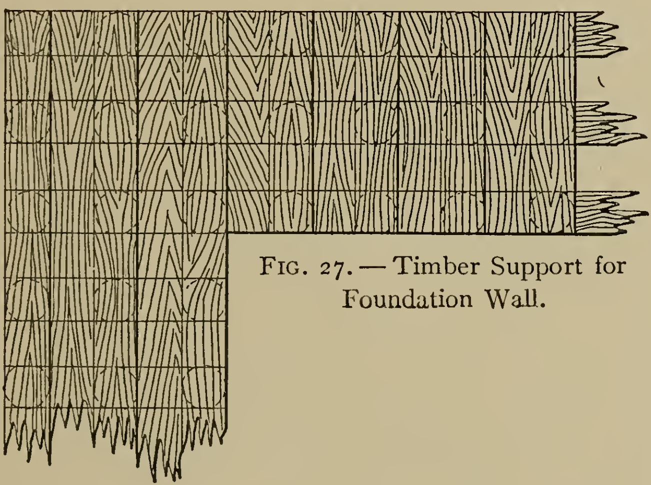


Fig. 27. — Timber Support for Foundation Wall.

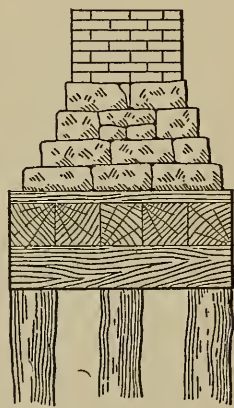


Fig. 28. — Piling and Timber Support for Foundation Wall.

Upon these piles timbers of sufficient size are placed, being laid across each row of piles; then upon these another course of timbers, at right angles to the first. These may be laid close together or two or three inches apart, the size of the timbers being determined by the weight of the wall they are to support. For instance, for the walls of the machine shop proposed in these articles, the timbers may be 10 x 12 inches laid on edge.

Fig. 27 gives a plan view of this method and Fig. 28 shows a cross-section

of the same. It is not always necessary to arrange the piles in three lines, with those in the center row in line with those of the two outer rows, as shown. Where the weight of the superstructure is not excessive it is often preferable to begin by setting three piles in a row, then two so they will come opposite the intervals of the first row; then the next row of three in line with the first; then another row of two piles and so on.

Where there is considerable depth from the top of the piles without side support it is necessary to drive "sheet piling." Set planks three inches thick, or thicker, with their edges close together so as to enclose the work on both sides, and afterward fill in the spaces between these planks and the solid earth with tightly rammed gravel, and if necessary fill the spaces between the piles with stones or concrete. This will give them quite sufficient support to make a very firm foundation bed and prevent any lateral movement which might result from the bending of the piles.

Timber should not be used under a foundation unless it is in a position to be kept continuously wet by the surrounding soil, for the reason that if always wet enough to exclude the air it will endure for a very long time, but if so situated as to be sometimes wet and again dry, it will soon decay.

Therefore, if the use of timber, as above described, is not feasible we must use stone and so arrange the piles, regarding the distances from center to center, as to allow the use of such stones as are available, cutting off the tops of the piles below the water line if possible, or at least so low as to have them always wet. This arrangement is shown in Fig. 29.

Fig. 29.—Piling and Stone Support for Foundation Wall.

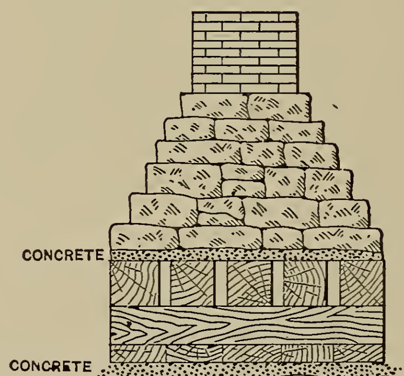


Fig. 30.—Timber and Concrete Support for Foundation Wall.

Sometimes fairly solid earth may be reached within a reasonable depth, but it requires digging quite a considerable depth beyond this before reaching really solid ground or "hard pan." In such a case it may be advisable to lay down, first, a course of concrete four to six inches thick, then a layer of timber and another course of concrete, which will furnish an excellent bed for the foundation.

The second course of timber may be replaced by a course of 3-inch planks if the wall is not a very heavy one. Circumstances might also warrant three courses of timber. The width of the timber work should be from two to three times the thickness of the wall. Fig. 30 shows such an arrangement.

A prominent public building has stood for many years on very soft and yielding alluvial soil, upon which such a foundation as that described above was laid over the entire area to be covered by the structure, and many feet deep. Then the stone foundation proper was built upon it, after which the very heavy and massive stone building was erected.

Where excavations vary in depth at different points of the same wall the ground should be cut out in steps, or "benches," so that the bed whereon the foundation is built may be perfectly level. The lower steps should be built in with as large stones as possible and brought up to the level of the more shallow parts. It will be readily appreciated that the larger stones require a smaller number of cement joints and will settle less, and consequently are less liable to disturb the work by yielding unequally. See Fig. 31. In all cases the excavation should be made below the reach of frost.

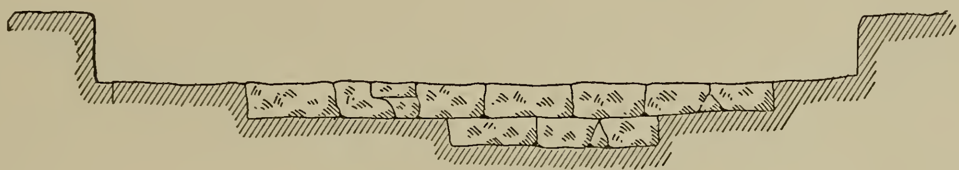


FIG. 31.— Benching out Ground for Foundation.

In building up a foundation of stones they should be laid with as near horizontal joints as possible so as to prevent the lateral movement of the stones by the weight put upon them. They should also be laid as far as possible in courses, and each course leveled off before commencing the next, the thickness of the courses necessarily depending on the thickness of the largest stones. These points are all the more important at corners, where tendencies to disintegrate are the most liable.

The foundation is laid considerably wider at the base than at the top, either in a wall gradually decreasing in thickness (that is, technically, with a "batter" of so much per foot, as in Fig. 32) or more commonly by a wide footing of one or more courses of larger stones. Above that it is built with regular vertical faces as shown in Fig. 33.

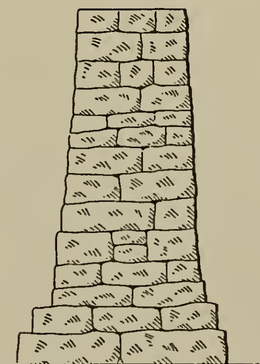


FIG. 32.— Battered Foundation Wall.

FIG. 33.— Straight Foundation Wall.

However the foundation wall may be built, the space between it and the

sides of the excavation should be filled in, either by tightly rammed earth or gravel, or better still by "puddling," that is, by flooding the space with water, throwing in the earth or gravel and allowing it to settle, ramming only from six inches to a foot of the top. The foundation of stone should be carried up above the level of the ground, from one to two feet according to circumstances. If the main floor of a building is to be raised several feet above the ground level, it is usual to build the foundation high enough to rest the floor timbers upon it, filling in the spaces between them with brick and leveling up ready for the brick wall.

The importance of using strong mortar in foundation work seems to demand that particular attention be paid to the proportions of its ingredients which will make the best compound of its kind. Use two parts of Portland cement, one part of slaked lime, and about three parts of clean, sharp sand.

The quantity of sand must be varied according to its fineness, sharpness, and freedom from dirt. A larger quantity of fine sand will be needed than of coarse. Some sand has a more rounded grain instead of the sharp angles of the better quality. Of such sand more must also be used.

Foundations are generally laid in mortar having a greater or lesser proportion of cement. They should also be stronger in this respect for the lower or underground courses than for the upper ones so as to better resist the action of water. In fact much of a foundation is frequently laid in mortar composed of only cement and sand, omitting lime altogether.

Thus far only the foundations for buildings have been considered. These have for their principal object to sustain the weights of the superstructure erected upon them.

In the case of the foundations for machinery it is quite different. Here not only the weight must be sustained but the question is complicated by the jars, strains, and shocks due to the operation of the machines; and this must also be considered. These vary largely in different cases, as for instance, the steady revolutions of a large lathe, the reciprocating motion of an engine, and the vertical concussions of the steam hammer or drop press.

Foundations for engines, large lathes, planers, boring mills and so on, are built in a manner somewhat similar to that for the foundation of a building, except that they are usually much broader at the base, conforming in a general way to that shown in end elevation in Fig. 34 and a portion of the side elevation in Fig. 35.

Only a good quality of hard bricks should be used, and the entire work should be laid in strong cement mortar.

The holding-down bolts, when it is necessary to use such fastenings, are made long enough to reach well down in the foundation, if not entirely through it, and are provided with large washers or plates at their lower ends. These

are put in place as the foundation is built up and their top ends are held in position by a templet made of boards in the form of a frame, and representing the base of the machine.

In a large foundation of this character, blocks of dressed stone should be worked into the finishing courses of bricks so as to bring them level with the top. These are usually placed crosswise, one at each end; and others at such points as to furnish firm support for the cylinder, crank shaft, pillow block, and guides of an engine; for the headstock of a lathe, and for suitable points along the length of the bed; under the uprights or housings of planers and at each pair of legs, or at proper intervals where the entire bed rests on foundations without the use of legs.

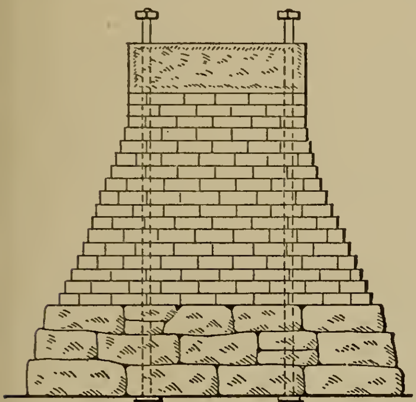


FIG. 34.—End Elevation of Engine Foundation.

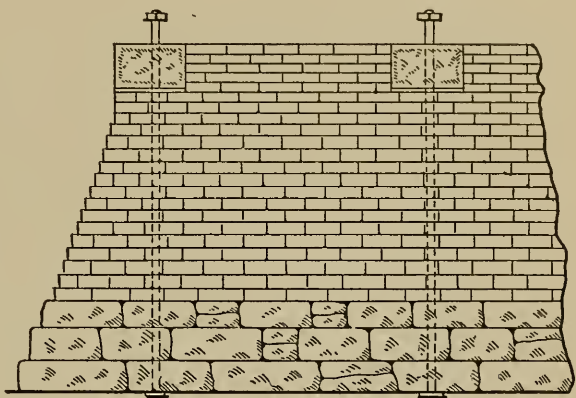


FIG. 35.—Partial Side Elevation of Engine Foundation.

Usually, in the case of a planer, and often of a large lathe, the foundation is composed of a series of piers built up separately at the points to be supported, each pier being capped by a stone of sufficient size to cover it.

In laying out the foundation for a planer of, say, 36 x 36 inches or larger, a pit should be provided under the center; that is, from a point one to two feet back of the face of the uprights to a point three to five feet in front of the uprights, and five to six feet deep. It should be broad enough for the building of narrow steps leading down into it.

This pit will receive a great portion of the chips produced, and in it, resting on large and firmly set stones, should be two cast iron columns, with strong jack screws tapped into their tops, and coming up into contact with the under side of the bed at a point near the face of the uprights. Thus arranged, they are very useful in maintaining the proper alignment of the planer.

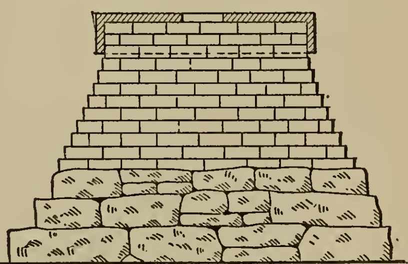


FIG. 36.—Special Pier for a Machine Testing Foundation.

A foundation now in use, upon which large lathes are erected and tested, was built as shown in Fig. 36. Solid ground was found about five feet below

the floor level, and a course of concrete was first laid, then three courses of stones, and upon these hard bricks, cement being used throughout.

Upon the top of each pier a cast iron plate $1\frac{1}{2}$ inches thick was placed. This plate had downwardly projecting flanges all around it, deep enough to cover three courses of bricks. In the top of these plates was a hole six inches in diameter.

When the brickwork was finished these plates were put in place and leveled up so as to leave about half an inch space between the plate and the top of the bricks. Around the lower edges of the flanges the space was carefully closed with cement. Then cement was mixed thin enough to flow easily, and was poured into the hole at the top until the entire space at the top and sides was completely filled, and the whole was allowed to "set."

The tops of the plates were about $\frac{1}{4}$ inch above the top of the floor, which was built up closely around them. Very heavy lathes are moved on and off these piers almost daily for several years without injury, and the piers have not settled to any appreciable extent, or so as to cause any difficulty in leveling up machines to be tested.

In placing high-speed engines or planers, which are liable to lateral shocks, it may be advisable to provide cast iron plates as described above, with the downwardly projecting flanges to cover the upper courses of brickwork, and also with upwardly projecting flanges enclosing sufficient space for the base, cabinets or legs, as the case may be. After leveling up the machine with steel wedges, say a $\frac{1}{4}$ to a $\frac{1}{2}$ inch, the space is filled with melted lead or brimstone, which when cool will form a very secure, serviceable, and durable arrangement.

Foundations for machines subject to considerable vertical shocks, such as steam hammers, drop presses, and the like, must be treated in an entirely different manner. From the nature of the work a solid foundation of stone and brick is not usually considered as best adapted to the conditions.

Such a foundation, unless formed of one solid block of stone, would soon be spoiled by cracks and disintegration from the shocks, and serious consequences to the machine might ensue, the parts broken, for instance, or the dies ruined. For such cases many experienced men prefer foundations that may be elastic enough to relieve the machines somewhat of the sudden strains and shocks of heavy and oft-repeated blows. In these cases the foundations are composed of timbers.

There are two common types of these foundations. The first one, for small or medium sizes of drop presses or hammers, are built with timbers set on end and firmly bolted together in sufficient numbers to form a foundation of the required size, as shown in Fig. 37, the bolts going entirely through the mass. Timbers 10 x 10 inches or 12 x 12 inches are

a convenient size, and hard pine is found by experience to be best adapted to the work.

The excavation is first made to solid ground, then a foot or so of hard gravel is tightly rammed down in the bottom, to form the bed. The timbers are cut of a proper length to reach the surface, but should not be less than 5 feet long. They are bolted together, lowered into place, and leveled up, and good hard gravel is tightly rammed in around the timbers, filling the space between them and the sides of the excavation.

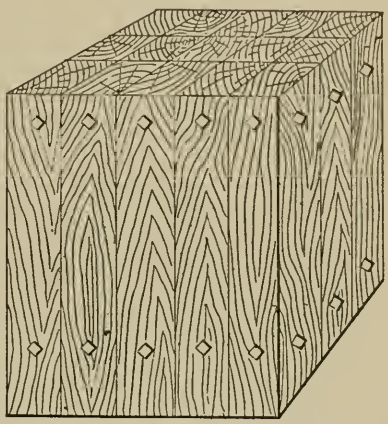


Fig. 37. — Drop Hammer Foundation.

This form of foundation is adapted for drop presses and small hammers in which the anvil is a part of the machine itself. In case a hammer is of such size as to have the anvil detached from the main frame, the latter is supported upon a stone foundation, or on one partly of stone and partly of brick (built in two piers for a double hammer), as shown in cross-section in Fig. 38 and in side elevation in Fig. 39. The foundation for the anvil is built of timbers laid horizontally, the base being spread over as large an area as practicable, in order to resist the force of the blows of the hammer.

In a double hammer the anvil foundation must be restricted in width, but may be extended in length at the base so as to present the form shown in the engraving.

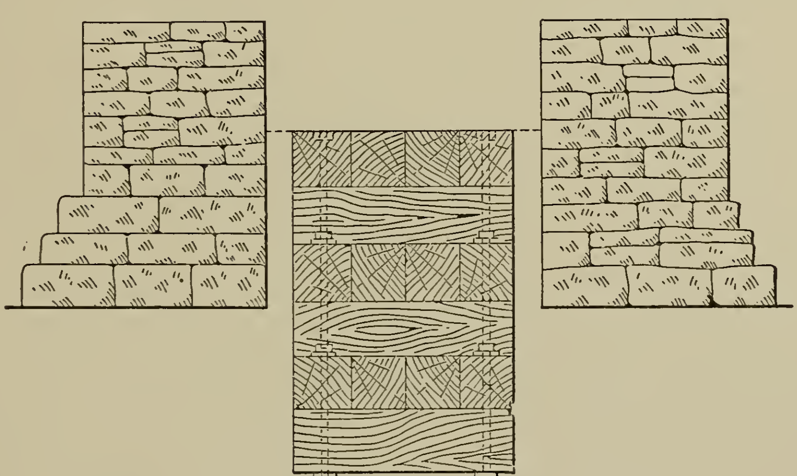


Fig. 38. — Cross Section of Steam Hammer Foundation.

The size of the foundation is necessarily proportioned to the size of the hammer, but approximately as follows: Supposing the width between the upright parts of the main frame to be 6 feet, the width of the timber work will be about 4 feet, the length on top 8 feet and at the base 12 feet — assuming the necessary depth to be 4 feet. If solid ground is not found at this

depth, the excavation may be filled up with hard gravel, stone or concrete; or a layer of concrete may be placed at the bottom, then a course or two of stone laid in cement mortar, and finally hard gravel well rammed in. The timbers should be bolted together at the corners or securely spiked, but owing to constant shocks, bolts are to be preferred. The top corners of the timbers should be bolted together horizontally. The masonry piers and timber foundations must not in any way be connected, as the constant concussions would soon disintegrate the masonry. All spaces around the masonry and timber work should be tightly rammed with hard gravel. The size of the timbers may be from 6 x 6 inches and larger, according to the size of the structure; but they are usually 10 x 10 inches or 12 x 12 inches. Timbers used in places where decay is feared should be coated with hot gas tar as a preservative.

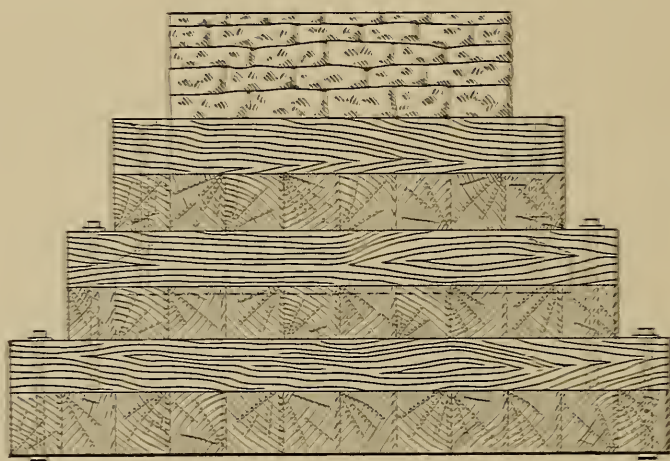


Fig. 39. — Longitudinal Section of Steam Hammer Foundation.

On one occasion, in soft and very yielding ground, a machine of forty tons weight was supported by a foundation built by excavating nearly 30 feet deep, piles being driven at 2 feet centers over an area about three times the width and length of the base. Upon these was built a timber structure in the manner described, up to within six feet of the surface of the ground, and gradually drawn in to four feet larger all round than the base of the machine, which was quite high in proportion to its width of base. On this timber work stone laid in cement mortar was built up to the level of the ground and the machine erected upon it. The foundation proved successful.

CHAPTER XI

THE CONSTRUCTION OF FLOORS

Earth and concrete floors. Vertical section. Stone and concrete floors. Vertical section. Paving. Simple steel supporting beams. All wood construction. How the grain of the wood should run, in planks. The wrong way to cut up the log. The right method. Quartering the log. The machine shop floor. Construction of the gallery floors. Wood joist construction. Steel construction. Floor planks. The floor that failed. Ventilation of wood floors. Another failure. The kind of wood to use. The foundry floor. Foundry pits. The forge shop floor. The boiler room floor. Kind of bricks for floor paving. Metallic floors. Engine room floor. Carpenter shop floor. The cupola platform, or charging floor. Wash room and water-closet floors. The office floors. Pattern storage floor. Kind of lumber to use. A floor of wood paving.

In the construction of modern manufacturing buildings there are many methods of constructing a floor, varying all the way from the almost primitive "dirt floor" of the forge shop to the close-jointed smoothly-finished hard wood floor of the modern watch factory.

Those which principally concern us in these articles, however, are such as are necessary in the modern machine shop, forge shop, iron foundry, etc., and these we may properly divide into six classes, viz.:

First, those composed exclusively of earth, as the floor of the forge shop.

Second, those composed of earth and concrete, like the floor of an iron foundry, as shown in vertical section in Fig. 40.

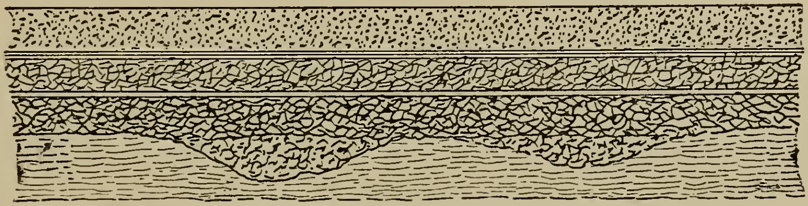


Fig. 40. — Vertical Section Earth and Concrete Floor.

Third, those of stone and concrete, as the main or ground floor of a machine shop designed for constructing and erecting heavy machinery, shown in Fig. 41.

Fourth, those composed of stone or bricks, as required for engine and boiler rooms, etc., shown in plan in Figs. 42 and 43.

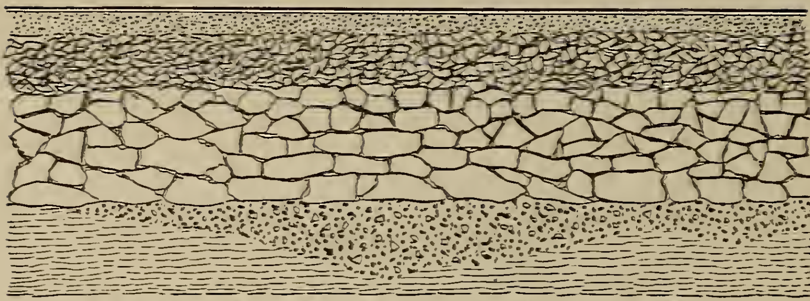


FIG. 41. — Vertical Section Stone and Concrete Floor.

FIG. 42. — Flag Stone Floor.

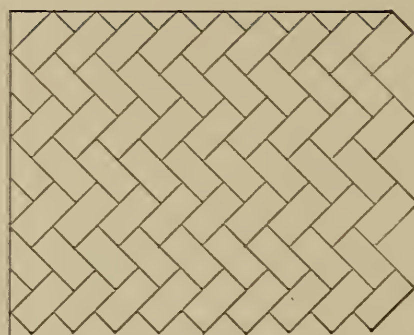


FIG. 43. — Brick Paving.

Fifth, those composed of wood, supported by iron or steel beams, as illustrated in vertical section in Fig. 44 and Fig 45.

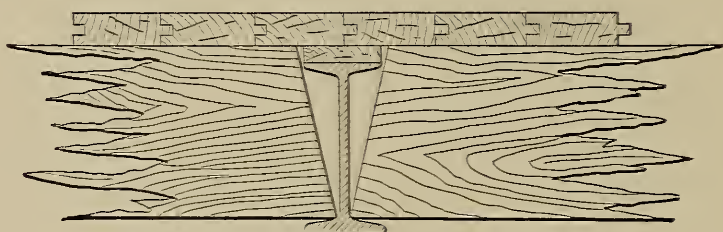


FIG. 44. — Simple Steel I-beam Support.

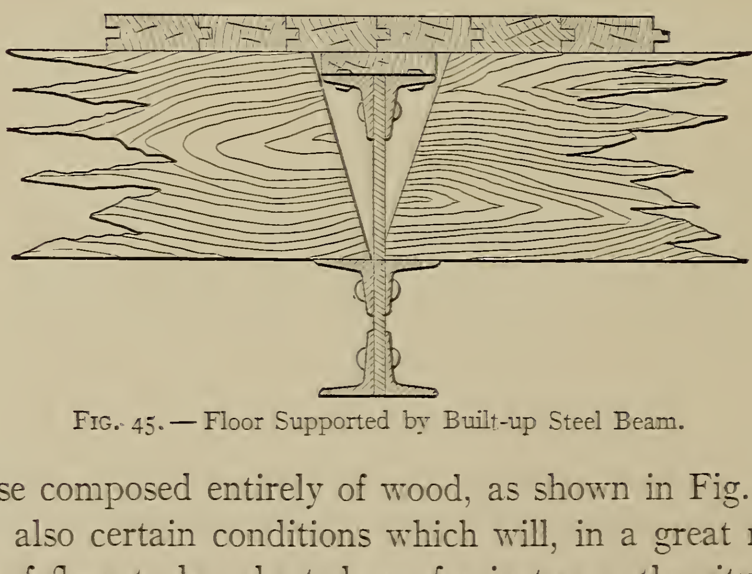


FIG. 45. — Floor Supported by Built-up Steel Beam.

Sixth, those composed entirely of wood, as shown in Fig. 46.

There are also certain conditions which will, in a great measure, determine the kind of floor to be adopted, as, for instance, the situation, the kind of work to be done and the weights which the floor will have to support.

As to materials, there are those of each kind which it might be perfectly

proper to use in other portions of the work of construction, but which would be objectionable in a floor.

Stone should be of such nature and quality as to remain firm and hard, with no disposition to crumble away. Hence granite is the best, although there are other kinds which are nearly as good for certain purposes, and much cheaper. Generally we use such as can be obtained near the work so as to avoid the cost of transportation.

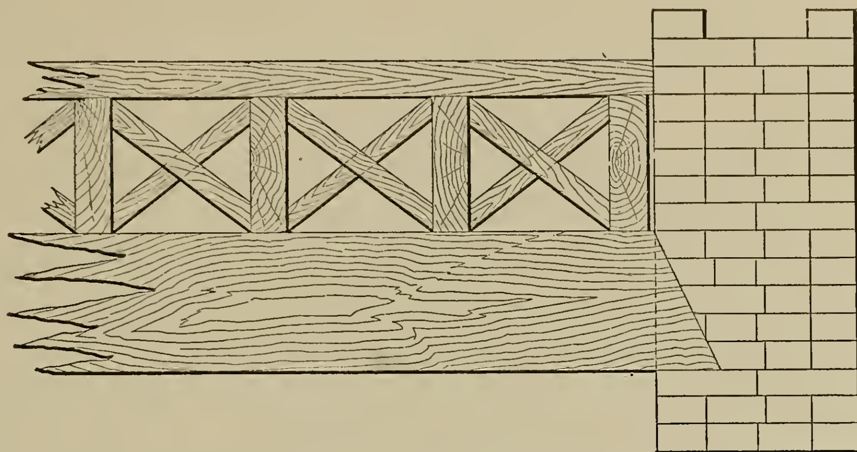


FIG. 46. — Floor with Wooden Beams.

For paving, a hard, smooth-surfaced stone is needed. Sandstone wears away easily, and therefore the harder varieties are preferable. Slate makes a very smooth-wearing and satisfactory floor. Granite is not usually employed for this purpose owing to the expense of obtaining it and the cost of cutting.

Paving bricks should be hard-burned and of a quality to insure toughness, so that they may not be easily broken by accident. Many brick companies, in different parts of the country, now manufacture bricks for street paving which possess as good wearing qualities as most kinds of stone.

Gravel should be free from soil, although a moderate quantity of sharp sand is not objectionable. When earth is used in making a floor a certain amount of clay should be added, to give an adhesive quality to the mass.

Sand should in all cases be clean and sharp, free from soils and alluvial earth, and not too fine.

Lumber should be so cut at the mill that the grain of the wood shall run as nearly as possible at right angles to the face of the board or plank, as shown in Fig. 47, rather than with the grain running in a direction nearly parallel with the face, as in Fig. 48.

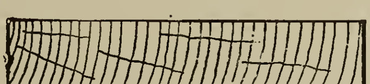


FIG. 47. — Plank properly cut from the Log.

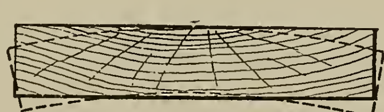


FIG. 48. — Plank improperly cut from the Log.

The reason for this is that the surface of the planks shown in Fig. 48 will

wear smoothly even under very hard usage, while in the other case it will easily splinter up and present a very unsightly appearance, and will not last more than half as long as when properly cut from the log.

Then, too, while the plank shown in Fig. 47 will warp very little, if any, that in Fig. 48 has a great tendency to warp, owing to the direction of the grain, and to the fact that the sap or outer portion of a log, being the newer growth, is less dense and consequently will contract more in the process of seasoning.

Therefore the tendency is to distort the plank to the form shown by dotted lines in Fig. 48.

Logs are usually cut up at the mill on the lines shown in Fig. 49. The boards taken off at the right and left, called "sidings," are trimmed on their edges separately and sold at a reduced rate, while the remaining center portion of the log is cut into stock boards, or planks of regular width and thickness.

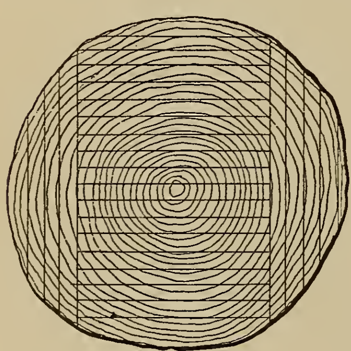


FIG. 49.

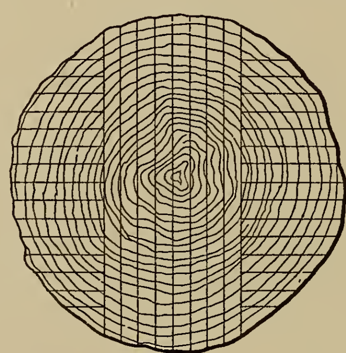


FIG. 50.

The Wrong and the Right Way to cut a Log into Boards.

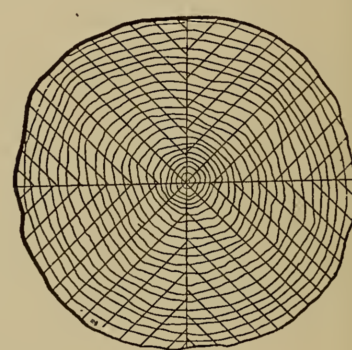


FIG. 51.
Quartering the Log.

To preserve the direction of the grain with relation to the faces of the boards or planks, the form of cutting shown in Fig. 50 would be advisable, but not as economical. This latter method is on the principle of quartering, as referred to in the furniture makers' term of "quartered oak," for instance.

This form of cutting is shown in Fig. 51. It gives comparatively narrow boards, is expensive, and generally used for expensive woods, and for expensive work, as for fine furniture.

The main or ground floor of the machine shop being intended to sustain moderately heavy weights, both of machines and materials — as well as the hard usage in moving them from place to place, and the shocks of heavy work — is now usually made of concrete, and laid as shown in Fig. 41.

In some cases those portions of floor included in the side wings are constructed of wood. This form is objectionable on account of the obstruction formed by the joining of the concrete floor and the planks; for at this point the former is apt to be cracked and broken, and the latter dented, split, and defaced.

This is particularly so if the planks are a trifle higher than the concrete, as is likely to be the case when newly laid down. Then, too, where such a floor is of wood it is necessary to excavate a foot or so below the floor timbers, to provide an air space for preventing the decay of the materials.

To lay a concrete floor for this purpose the earth should be excavated to the depth of from 18 to 24 inches, according to the weights which the floor is to carry.

For ordinary purposes of machine shop work 22 inches is desirable and sufficient. If the ground is sufficiently firm at this level, no further preparation need be made. If soft and yielding, the excavation should be carried down to solid ground, and then filled up with solid earth, or still better with gravel, the excavation being flooded with water and the filling material thoroughly puddled as it is put in.

On top of this bed should be placed a layer of coarsely broken stone, from 8 to 12 inches deep; and upon this a layer of crushed stones, none of which should exceed 2 inches in dimension. This layer should be from 4 to 6 inches thick. On this is spread a layer 2 to 4 inches thick of concrete composed of one part Portland cement, two parts clean, sharp sand, two parts clean gravel, and three parts fine crushed stone — all taken by measure, and not by weight.

These ingredients should be mixed rather wet so as to settle well down into the spaces between the stones of the previous course. The concrete should be rammed hard and made perfectly level.

Then comes a coating of from ½ to 1 inch thick, consisting of a mixture of one part Portland cement and two parts clean, sharp sand, which should be laid before the former course is dry, in order that the two courses may firmly unite. This last course is laid quite wet, to facilitate "floating" — that is, the leveling off and smoothing.

Sometimes the intermediate course of concrete work is made up of shingle (coarse gravel, stones, or pebbles), mixed with hot coal tar or Portland cement; but this has the objection that, whatever be the medium used for cementing the mass, it will not adhere to the rounded surfaces of the pebbles as effectively as it does to the more porous surfaces of crushed stone.

Therefore, where subjected to hard usage, this shingle is more likely to disintegrate and break up than where crushed stone is used.

The gallery floors of the machine shop are supported on built-up girders 20 inches deep, placed at each of the columns dividing the wings from the central part of the building. Carried upon angle bars, riveted to the girders at a proper height, are the ends of 3 x 16-inch floor joists, placed 20 inches from center to center, their upper edges coming 2½ inches above the top of the girders, which space is occupied by a spiking piece. On these joists is

laid a floor of $2\frac{1}{2}$ x 6 inch planks, planed on both sides and matched with tongue and groove.

This construction is shown in vertical section in Fig. 52. The girders here shown may, of course, be solid I-beams, with angle bars riveted on them for supporting the ends of the joists.

Where a lighter construction may be safely resorted to, on account of less weight to sustain, the form shown in Fig. 44 is proper. In this case an I-beam is used, say 10 to 15 inches deep, and the ends of the joists rest upon the lower flange of the beam. They should be of such depth as to project a couple of inches above the top of the beam, as shown, to provide a space for a spiking piece.

In either case the ends of the joists should be beveled as shown, so that they may drop out clear in case of fire, without displacing or warping the I-beams.

Wood joists may be dispensed with altogether, if safety from fire is of more consideration than first cost.

In this case I-beams of proper strength are laid upon the girders, or with their ends resting upon the lower flanges thereof — say 4 to 8 feet from center to center — and upon them are laid planed and matched floor planks from 3 x 6 inches to 5 x 8 inches, according to the distance between supports and the load to be sustained. These are bolted to the upper flange of the I-beam. This arrangement is shown in Fig. 52.

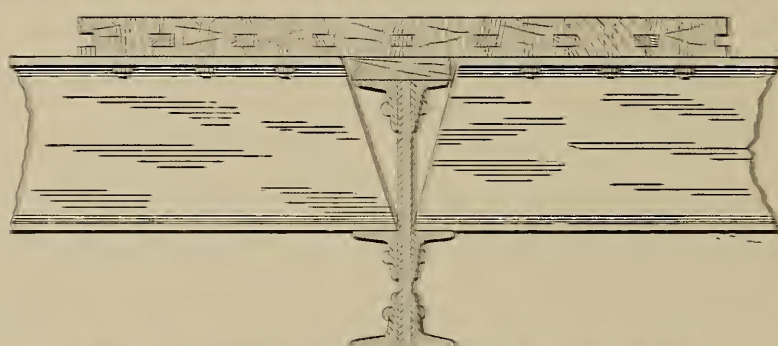


Fig. 52. — Floor Supported Entirely by Steel Beams.

The vertical space occupied by these methods of construction varies considerably, as is shown in the engravings, and must be taken into account in designing the building.

Where it is desired to support floors by wooden beams, the form shown in Fig. 46 is proper. The dimensions of the beams must be sufficient to carry the load, taking into consideration also the distance between supports. The ends of the beams resting in the brick wall should be upon a "header course" of bricks, as shown, and the ends of the beam beveled off the same as if used in connection with an iron girder or I-beam, so that in case of fire the beam will fall freely out of the wall without injuring it.

Floor joists are laid upon the beams in the usual manner and spiked to them. Wooden floor joists should be braced by a "bridging" of say 2 x 3 inch scantling, as shown, placed at intervals of from 6 to 8 feet, according to the dimensions of the joists and the weights they have to support.

In using floor planks of 3 inches or over in thickness it will be found more economical to groove both edges of the planks and insert a separate piece as a tongue, than to cut a groove in one edge and a tongue in the other.

The selection of proper lumber for floors has already been referred to. It is often profitable to consider those things that have failed since it has been well said that "we learn as much by one failure as by two successes." And the failures in shop floors are prolific sources of much annoyance and expense.

A certain machine shop floor was laid upon round chestnut timbers, flattened on top and bedded in gravel laid over "made land," that is, loosely filled in with refuse matter of any sort easy to obtain. The floor proper was of 2-inch spruce planks.

The result was that within a year the chestnut timbers and the under side of the planks began to decay, and since that time about one half of the timbers and nearly all the floor planks have been replaced each year, the patching-up process going on at intervals, and the constant result being an unsightly as well as expensive and annoying affair.

Within a hundred feet of this floor was another of 2-inch planks laid on 3 x 12 inch joists, supported on 12 x 12 inch timbers resting on piers, raising the floor about two feet above the ground.

Twelve years after this was laid some planks were removed to put in a machine foundation, and the joists and timbers were found looking nearly as fresh and new as when they came from the lumber yard.

Their elevation above the ground and the ventilation of this space by small gratings in the side walls were evidently the cause of their preservation. These cast iron gratings, say 10 x 18 inches, should be inserted at least every fifty feet in the walls of buildings whose ground floors are of wood, and at least a foot of ventilating space should be left between the ground and the floor.

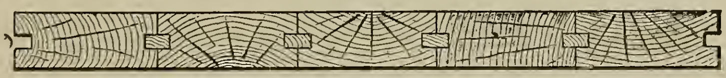


FIG. 53. — A Floor as Originally Laid.

Another example, equally instructive, was a second floor of a machine shop. It was of $2\frac{1}{2}$ x 6 inch spruce planks, properly supported. They were grooved on each edge $\frac{3}{4}$-inch wide and strips were inserted as shown in Fig. 53.

The builders evidently thought that planks $2\frac{1}{2}$ x 6 inches, with inserted tongues, would make a good and substantial floor. And so they would have,

but the unfortunate selection of the planks included many with the grain running in the wrong direction, which caused much warping and distortion.

Fig. 54 is from a sketch taken at the head of a stairway, careful attention having been given to the direction of the grain and the distorted form of the planks. It is, perhaps, needless to say that the tongues were split, and in some cases the planks also.

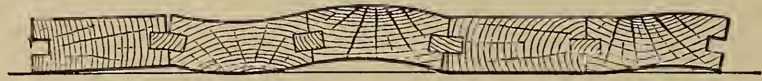


FIG. 54. — The Floor as Warped out of Shape.

Formerly the timbers most used in ordinary construction were of spruce. While this wood is well adapted for floor planks, it has very serious objections when used as supporting timbers. There is great liability to warp, twist, and crack as the seasoning process goes on, while its strength is not as great as some other easily obtained woods.

For instance, hard pine is superior in this respect, while it is about 35 per cent stronger than spruce, and its usual cost is only about 20 per cent greater.

The foundry floor is subjected to a very considerable weight, both in molding sand and in the castings produced, but the rough usage and shocks which the machine shop floor is called upon to withstand are not met with here. Consequently there is no need of such an expensive preparation.

The ground is prepared in the same manner as for the machine shop floor, except that it is only 12 inches below the floor line. This space is first covered with a 4-inch layer of crushed stone, over which is poured a thin mixture of one part Portland cement and two parts sand, mixed rather wet.

Then a concrete is made of the same mixture and finely crushed stone, and laid to a depth of about 3 inches. On top of this is spread a flowing coat of the cement and sand mixture from $\frac{1}{2}$ to $\frac{3}{4}$-inch thick, which is properly leveled off. All this having thoroughly set, the remaining portion of about 4 inches is made up of molding sand.

Pits are dug in the central portion of the foundry floor, of such number, area, and depth as the contemplated work renders necessary. The bottom is covered with 6 inches of concrete and laid with two courses of hard bricks. The side walls of the pits are 8 inches thick and are built of hard bricks, all laid in cement mortar.

The top of the wall is level with the final cement coat of the floor. If castings of ten tons or over in weight and with comparatively small bases are to be made in one of these pits it will be necessary to put down a more substantial bottom.

Excavation should be made to solid ground, or "hard pan," and large stones laid in cement mortar built to within about a foot of what is to be the

bottom of the pit. Then proceed as above for making ready for the side walls. Care should be exercised in ramming or puddling, or both, to completely fill in around the side walls.

The floor of the forge shop is a still more simple matter than that of the foundry. The ground is prepared as before, and leveled off a foot below where the top of the floor is to be. This space is filled in with clean gravel mixed with clay, in the proportion of three parts of the former to one of the latter, laid down wet and thoroughly rammed down with a broad-faced rammer.

Sharp sand, or the fine cinders from forges, are sifted over this to prevent the surface from becoming muddy when accidentally wet. In the case of a forge shop, concrete is hardly advisable, being liable to be broken up by the heavy shocks from hammers and the rough usage to which it would be subjected.

Of course it might be made thick enough to endure these conditions, but would be quite expensive and would answer the purpose no better than a hard-rammed floor of earth, as above described.

For the floor of the boiler room, flag-stones or hard-burned bricks may be used, whichever is found most convenient. If stones are used they should be cut to a certain width, in one direction at least, in order that they may be laid in courses so as to "break joints," as shown in Fig. 42. They should be from 1½ to 2½ inches thick.

Supposing the ground to be sufficiently solid for the purpose, it is prepared by leveling, the same as heretofore described, and at least 4 inches plus the thickness of the stones below where the top of the floor is to be. Sharp sand should be filled in 4 inches deep, and the stones laid upon this, the sand being rammed closely under each course as laid.

When completed, dry sand to the depth of ½ inch is spread over the whole and swept back and forth to force as much as possible down through the joints. This is the cheaper and more simple method.

If it is desired to make a more substantial pavement, the earth should be leveled off at such a height that only an inch space is left between it and the stones, and an inch course of a mixture of one part Portland cement and two parts of sharp sand worked up rather soft.

The stones are laid on this while it is wet, and all spaces filled as each course is laid and leveled. Some masons may prefer to make this mixture with a portion of lime added, the same as in cement mortar.

Should bricks be used they may be laid on either the sand or cement bed the same as described for stone, except that about half the depth of sand will be sufficient. They should be arranged in the form shown in Fig. 43, by which method they are firmly bound together, and, if laid only upon sand,

will retain their places for a long time. They are in some respects to be preferred to stone.

Where the ground is soft or has soft spots, it will be necessary to excavate to comparatively hard ground and then fill in with solid earth — preferably gravel — which is to be tightly rammed or puddled to make it firm. Upon this the layer of sand may be placed as described.

It is sometimes desirable to have engine room floors paved also, and occasionally with much larger and heavier stones than those described above. They should be carefully laid in cement mortar on a good concrete bed.

If rolled iron plates, or cast iron plates are to be used they should be supported by brick piers and iron bars, or by brick walls supporting their ends, and at other points if their dimensions render it necessary.

Cast iron plates may be made with strengthening ribs on their under side, by which means the supports may be much farther apart. Plates of rolled sheet steel with raised figures of various forms and patterns can be had, which make an excellent floor for engine or boiler rooms.

The modern engine room is a much better appointed department than formerly. It should have a floor of narrow, matched hard pine, smoothly leveled off by hand planing, and the surface kept oiled with boiled linseed oil.

The floor of the storehouse is of 2-inch planks, laid on 3 x 12 inch joists placed 15 inches from center to center, which in turn are supported by timbers 10 x 12 inches, placed 10 feet apart from center to center and resting on piers, leaving 15 feet between supports.

It the load which this floor is to carry warrants it, this distance should be reduced to 10 feet. The floor planks may be matched if desired, but for a floor for heavy machinery storage they need not be either matched or planed.

The carpenter shop floor is of similar construction to the above, except that the joists are 2 x 10 inches, laid 18 inches from center to center, and supported at distances of 13 feet by 8 x 10 inch timbers, resting on piers 10 feet apart.

The cupola platform or charging floor of the foundry is of 2½-inch planks laid on 3 x 12 inch joists, placed 12 inches from center to center, and supported in their centers by a 10 x 12 inch beam, whose ends rest in the brick walls, and its center upon an 8 x 8 inch post. The floor, at least in the vicinity of the cupola, should be protected by sheet iron smoothly nailed down.

If preferred, the floor may be constructed entirely of iron. In this case, plate girders or I-beams should carry cross supports and the floor be composed of cast iron plates reaching from one support to the other, and having supporting ribs cast on their under sides.

This form would, of course, make a much better method of construction, and in such a situation, much safer from the danger of fire, although more expensive.

The floors of the wash rooms in the power house are of $1\frac{1}{2}$ x 6 inch matched planks, planed on both sides, and laid on 2 x 12 inch joists placed 16 inches from center to center. Iron or steel floors may be here used to advantage on account of the disagreeable odors produced by saturated wood floors.

Floors in the office building, including the drawing room and pattern shop, are laid with a lining of ordinary pine $\frac{7}{8}$-inch thick, and covered by $1\frac{1}{8}$-inch hard pine, planed and matched, and not over $3\frac{1}{2}$ inches wide, with the grain of the wood as shown in Fig. 47.

The floors are laid on 3 x 12 inch joists placed 16 inches from center to center and supported by 10 x 12 inch beams set 12 feet from center to center.

For the second floor these beams are supported on iron columns in the office and on 8 x 8 inch posts in the tool room, set 16 feet apart, making four posts or columns in the building 50 feet square, outside measurement.

The timbers of the ground floor are supported on brick piers rising from the ground, which is excavated to a depth of at least three feet below the floor. One of these piers is under each post or column.

In place of wooden beams and joists, iron or steel girders or I-beams may be introduced, making a construction more nearly fire-proof, particularly for the second floor, but adding materially to the expense.

The floor of the pattern storage loft is of $1\frac{1}{2}$-inch matched planks laid on 3 x 12 inch joists placed 16 inches from center to center and supported by I-beams 15 inches deep, one end resting in the front wall and the other on an 18-inch box girder carrying the rear wall and resting on iron columns, as shown in the plan.

As to the kind of lumber used in the floors of manufacturing buildings, spruce is by far the most common, and if properly selected is best for all ordinary purposes. Hard pine makes an excellent floor and is preferable where extra expense is not an obstacle.

Occasionally, when cost is a secondary consideration, and a perfectly smooth surface is necessary, floors of hard maple are laid and carefully surfaced off by hand-planing. This makes probably the most durable of any of the wood floors.

The author saw a floor about 125 x 250 feet, prepared with a concrete bed and then laid on the wet flowing coat with hard maple blocks 2 x 4 x 12 inches, laid on edge, and in the "herring-bone pattern" shown for bricks in Fig. 43. After the concrete had thoroughly set the surface was hand-planed and oiled.

Of whatever kind of wood floors are made the material should be well seasoned, and if shrinkage cracks are to be avoided, the narrower the planks are the better, although 3 inches may be the minimum width.

If they are 3 inches thick or more, then 6 inches should be the minimum width.

CHAPTER XII

THE SYSTEM OF HEATING AND VENTILATION

Various heating systems. Leaking steam pipes. The condensation nuisance. Hot water heating. Hot air furnace. Of heating and ventilation. General requirements of a heating system. Form, size, and location of pipes. Construction of elbows, tees, Ys, and branches. The heating apparatus for the machine shop. Plan and cross-section. Heating surface required. General plan of the system. Location of the heating apparatus. Power for driving fans. Steam for heating. Heating apparatus for the foundry. Plans and cross-sections. Heating the office building. Plans and longitudinal sections. The proper temperatures for the different buildings.

THE construction of our several buildings being now completed and all arranged with proper consideration of the existing conditions and the expected circumstances by which we shall be governed, it is necessary that we should arrange for their proper and efficient heating and lighting. In this article the first of these questions, that of heating, will be considered.

There are many systems of heating buildings, among which are: By means of exhaust steam or of live steam, in lines of pipe arranged overhead or along the walls; by coils or radiators; by hot water utilized in a similar way; by air heated by furnace arrangements or by contact with pipes through which steam flows. All these systems have their good and bad features, both as to their warming qualities and their cost, as well as the expense of operating them. The hundreds of feet of steam pipes, with their numerous fittings, furnish at each joint opportunities for leaks, and special arrangements must be made to keep them clear of water. The distance from the boiler to the further end of long systems frequently requires much time to force enough steam to these points to warm the rooms so that they will be endurable to workmen.

The hot-water system works slowly and the temperature of the surrounding air rises gradually, so that the hour for beginning work in the morning must be anticipated by such a length of time as to be a serious drawback to complete success. The hot-air furnace gives air from which much of the moisture is evaporated and which is therefore unwholesome, aside from the fine dust so often brought along with it. In all these systems heating is the only end gained, ventilation being left largely to chance.

The ideal system of warming and ventilation would seem to be that in which fresh air, warmed by steam heat, is distributed by a suitable mechanical process, as evenly as possible to every part of the building, and one in which this can be done in the shortest time (as in most shops the heat is not maintained during the night except at sufficient temperature to prevent freezing of water pipes, etc.), and in which cold air may be readily introduced whenever needed.

This seems to be best accomplished by drawing fresh air from without the building, passing it through a heating apparatus consisting of an iron case containing a large number of steam pipes, and, by means of a fan and suitable pipes, distributing this warmed air to every part of the building by numerous outlets. The whole should be controlled by proper dampers, by which a due proportion of warm and cold air may be furnished as needed, so that proper ventilation as well as warming may always be maintained.

In the warming of such large buildings as those under consideration it is not necessary to draw cold air from the outside atmosphere to any great extent. The number of cubic feet of air contained in the building is largely in excess of that required for each person; and, moreover, cold air comes in through frequently opening large doors, while the swinging windows at the roof may be opened when necessary to permit the vitiated air to pass out, thus providing ample ventilation.

Many pages might be written on this subject, but space permits only a few general requirements which are practically indispensable, and may be summed up as follows:

The heating apparatus should be located near the center of the building so as to distribute the warm air to all points with the least amount of piping.

Openings should be so arranged as to be not over 30 feet apart, and to open toward the outer walls of the building. They should not be less than 8 feet above the floor, nor less than 5 inches diameter, and usually incline downward at an angle of about 10 degrees. The aggregate area of openings should exceed the area of the main pipe at the fan by about 25 per cent.

About 6 square inches area of openings should be allowed to every thousand cubic feet of space contained in the building — or room, where the building is so divided. The velocity of air should not be less than 1,500 feet per minute, and a sufficient quantity should be supplied to change the air every 15 to 20 minutes.

The pipes are preferably circular, as less material is required to make them of this form; furthermore, the circular pipes are stronger, and there is less friction of air in passing through them. For instance, a circular pipe 5.65 inches in diameter will have an area of 25 square inches and its circumference will be 17.88 inches. A square pipe 5 inches each way will also have

an area of 25 square inches, but the sum of its four sides will be 20 inches. A rectangular pipe 2 x 12.5 inches will be of equal area, but the sum of its sides will be 29 inches, or about 1.6 times greater than the circular pipe.

Nevertheless it often happens that square or rectangular pipes are necessary, on account of lack of space. When such is the case this area of cross-section must be increased accordingly, so as to avoid undue friction. Galvanized iron is the most desirable material for these pipes and is almost universally used where pipes separate from the building construction are employed. In factory buildings having several floors, proper flues and air ducts are arranged in the walls, and in the basement, where the heating apparatus is usually located.

In constructing pipes several important rules must be observed. In making a change of direction of 90 degrees the elbows should be made of not less than 5 pieces, and the radius of the inside of the bend should not be less than the diameter of the pipe, as shown in Fig. 55.

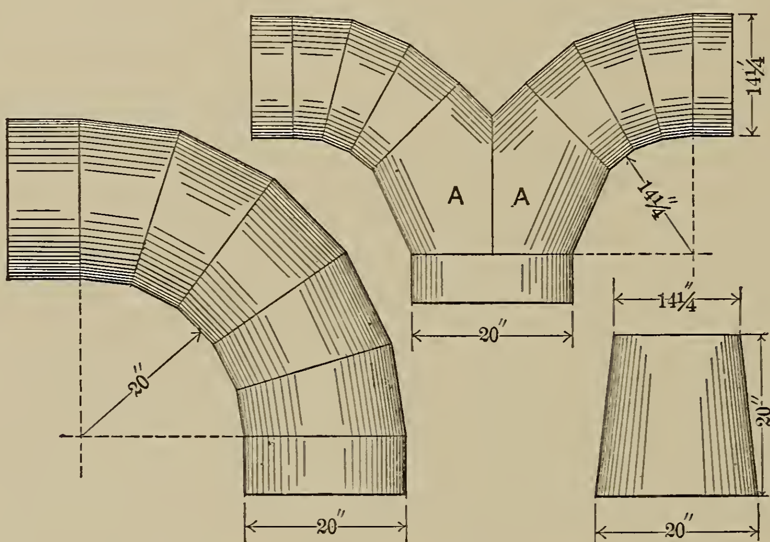


Fig. 55. Heating Pipe Elbows.

Fig. 56. Heating Pipe Y.

Fig. 57. Heating Pipe Reducer.

Where a main pipe is divided, the construction should be as shown in Fig. 56, the pieces *A A* being the frustum of a cone whose diameter at the base and whose height are equal to the diameter of the main pipe, and whose smaller end is equal to the diameter of the branch pipe, as shown in Fig. 57. This pipe is then cut to the proper form to fit its counterpart, as shown in Fig. 56.

Where branches are taken off from a main or leading pipe they should be so arranged as to leave the larger pipe at an angle of not over 45 degrees, and the inside radius should be not less than their diameter, as shown in Fig. 58. The contraction of the leading pipe, due to the taking off of this branch, should be made by the next sheet, the sheets being usually 30 inches wide.

This reduction of area should not be quite as much as the area of the branch pipe.

The further the air travels from the fan, the less force it has, and this should be compensated for, as far as may be, by slight allowances in area as the various branches are taken off, bearing in mind that this allowance should finally lead up to 25 per cent excess of outlet areas over the area of the main pipe at the fan.

In offices and comparatively small rooms the outlets are usually in the form of rectangular registers placed in the side walls near the ceiling. The area of these should be from two to three times the area of the pipe leading to them.

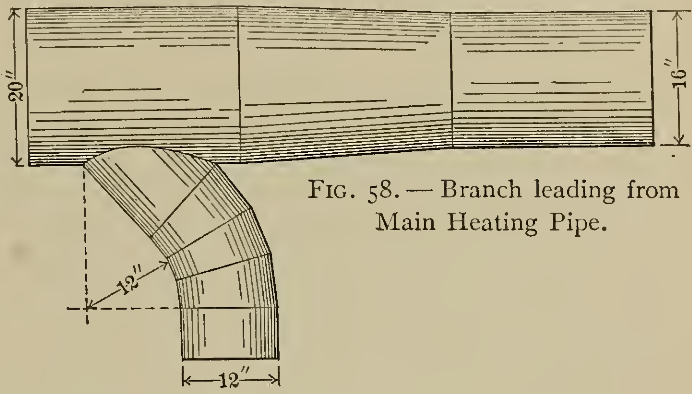


FIG. 58. — Branch leading from Main Heating Pipe.

Fig. 59 shows the plan of the arrangement of the heating system of the machine shop and Fig. 60 a cross-section of the same, giving the diameters of the pipes at various distances from the heaters; and the number, direction, diameter, and location of the openings, not only for the machine shop proper but for the carpenter shop, wash rooms, etc.

The heating apparatus consists of a rectangular iron case containing a large number of steam pipes of practically U-shaped form, inverted and connected to a cast iron base in such a manner that one leg of the pipe connects with the space through which the steam is admitted and the other leg connects with the space from which the drip is taken. These pipes should be located as close to each other as practicable, the rows of pipes being set "staggering" so as to break up the currents of air. The casing which surrounds them and connects with the inlet of the fan should also be formed as closely to the pipes as may be, in order that all air which is drawn through may come into close contact with the heating surfaces of the pipes.

It is customary to allow one foot of 1-inch pipe, or its equivalent, to each 100 to 150 cubic feet of contents of the building to be heated, when all the air is taken from out-of-doors. In the case under consideration, with one half or more of the air from within the building the higher figure would probably be ample. At the end opposite the fan are located dampers for regulating the amount of air supply. One of these may be connected with a cold-air duct from out-of-doors, where necessary.

Referring to Figs. 59 and 60 the location of the apparatus is seen to be in the gallery floor, near the center of the building. The fan has two discharge

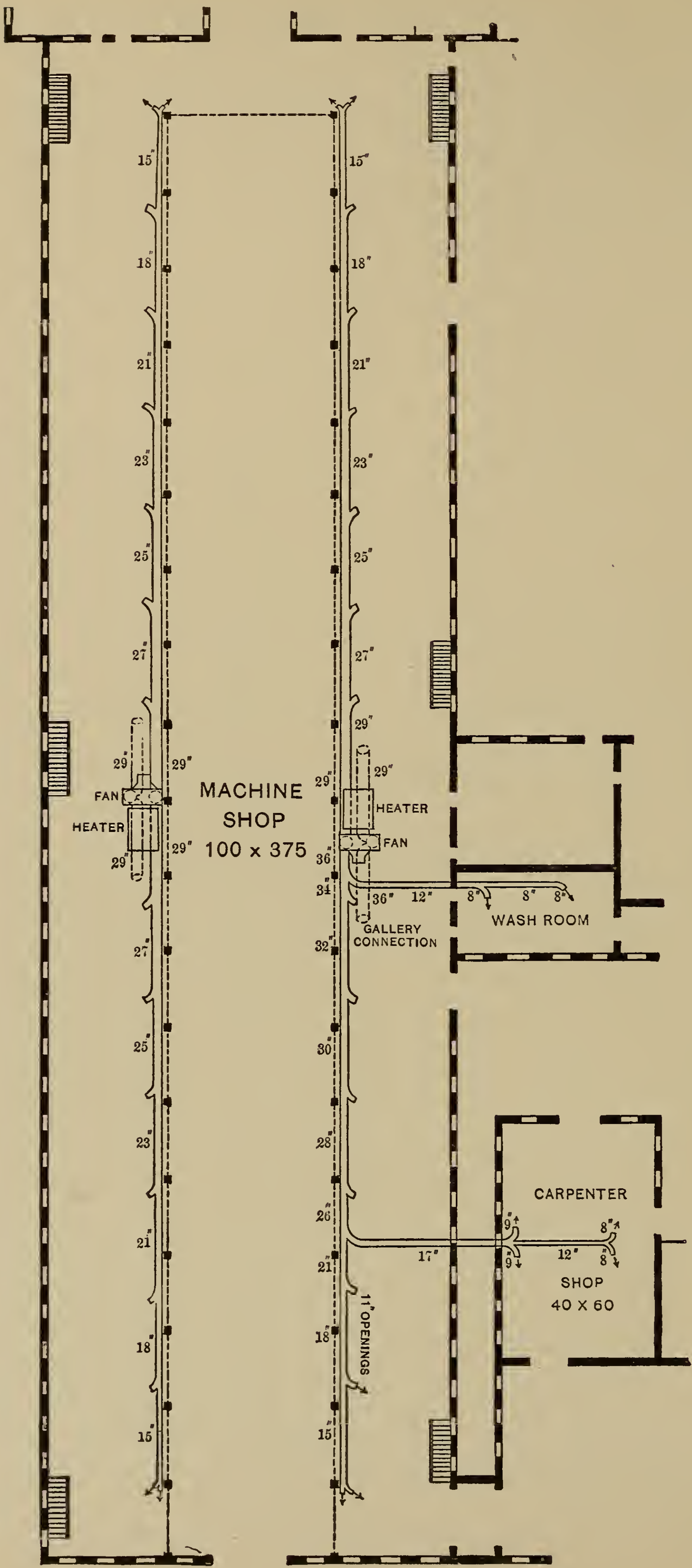


Fig. 59. — Plan of Heating System for Machine Shop.

openings, one downward for warming the side wings of the first floor, and one at an upward angle for the same service on the gallery floor. The returning

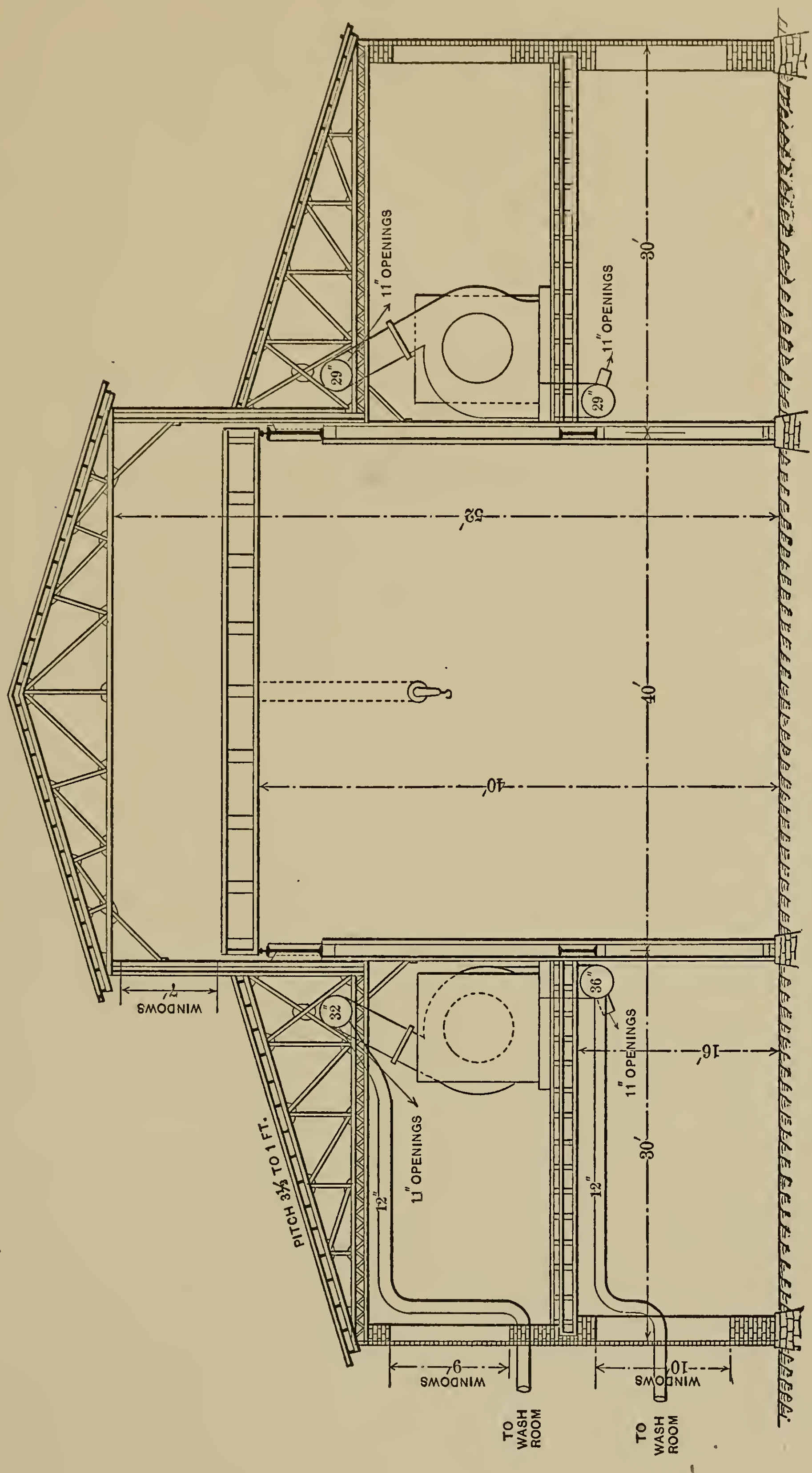


Fig. 60. — Cross Section through Machine Shop.

currents of air flow into the central portion of the building and warm that portion in their upward course.

Two sets of apparatus are used, for the reason that the traveling crane over the central portion of the shop prevents convenient connections between the two sides; and further, that the space to be heated is so large that the questions of convenience and economy are best met by this arrangement.

The apparatus on the side nearest the power house will require a fan with a wheel say 100 inches diameter by 52 inches wide, and running at about 185 revolutions per minute. This will supply from its downward opening the pipes for the main floor, including that leading to the carpenter shop and to the wash room on the first floor; and from its upward opening it supplies the pipes from the gallery floor, including one for the wash room on the second floor.

The apparatus on the opposite side of the shop should have a fan with a wheel say 90 inches diameter by 48 inches wide, running at about 205 revolutions per minute. The pipe connections are similar to the first apparatus, except that there are no long branch pipes to be provided for. Hence, while a 36-inch pipe is necessary for the side toward the power house, in order to warm the carpenter shop and the wash rooms, one of 29 inches diameter will be quite sufficient for the opposite side. It should be said that the dimensions given on the drawings are from actual calculations, taking into consideration all the circumstances of the form and dimensions of the buildings, and they will probably be found correct in practice as in theory.

The openings for the discharge of warm air into the building are directed toward the outer walls and downward at an inclination of about 10 degrees. This arrangement is clearly shown in the drawings, Figs. 59 and 60.

The pipes should be well riveted as they are put up, and securely fastened so that they may not be loosened by any jarring or vibration, either of the building or that caused by the pressure of air passing through them.

The fans may be driven by an electric motor or by an engine attached to each fan; or, if preferred, by belts from the main line of shafting. Any of these methods is efficient and has its particular advantages. If an engine is used, the large fan will require it to be of about 27 horse-power and that for the other fan should be of about 20 horse-power.

Live steam being used for heating, the large apparatus will probably require a supply pipe of 6 inches in diameter and the smaller one of 5 inches. The apparatus should be so constructed that a section of it may be separately connected for using the exhaust steam from the fan engine. In the same way the exhaust from the main engines of the works may be utilized and thus save a considerable portion of the live steam required.

In arranging for heating the foundry, different conditions are met with. With the exception of the chipping and pickling room heat is required hardly more than half the time, that is, during the forenoon, and perhaps for an hour or more after the dinner hour, as the heat from the cupolas is considerable.

The general plan of the system is the same as that employed in the machine shop. The apparatus requires but little room on the floor and consists of a fan having a wheel about 78 inches in diameter and 24 inches wide, running at about 400 revolutions per minute, and will require about 6 horse-power to drive it.

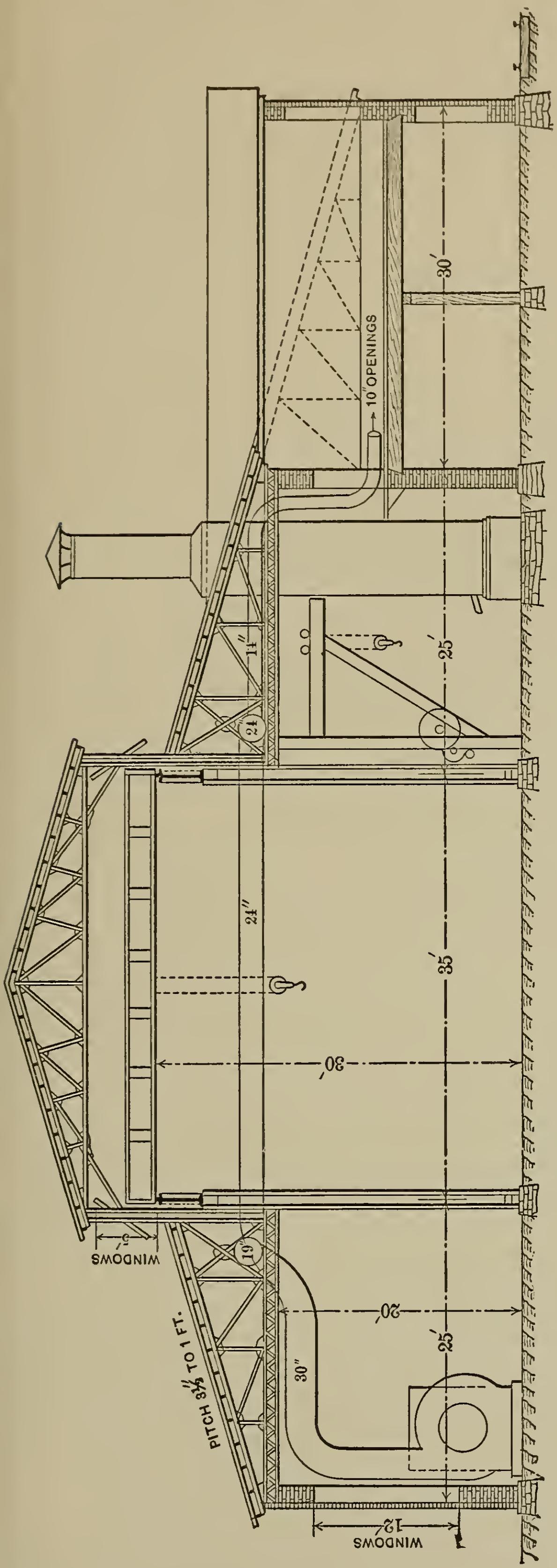


FIG. 61. — Cross Section through Foundry, Cupola, Platforms, etc.

An arrangement of pipes can, of course, be made whereby the chipping and pickling room could be warmed independently of the foundry proper, but it would probably not be necessary.

Figs. 61 and 62 show the arrangement of the foundry system of heating, with diameters of the pipes and openings. It will be preferable to run this fan by an electric motor or a small engine, and since these fan blowers for heating purposes are now made with simple and compact engines attached to them, which require very little attention, aside from starting, stopping, and oiling up, they are very convenient in such situations.

It is always important to have the heater as near the space to be warmed as possible.

The office building, including the pattern shop, drawing room, and tool department, is heated by an apparatus located in the tool room and forming a separate system.

Fig. 63 gives plans of the first floor and Fig. 64 that of the second floor. Fig. 65 is a longitudinal section through the building. A heating apparatus of the same size and capacity as that used in the foundry is employed. It may be driven by a separate engine, or a motor, or belted from the shaft which drives the machines in

the tool room. This latter plan is probably the best, since the power is convenient, and the first cost may be lessened without sacrificing any desirable feature in another direction.

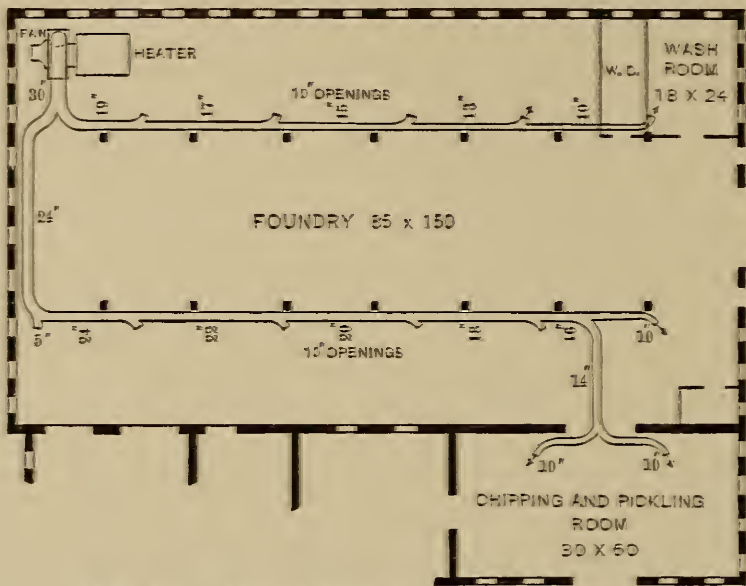


Fig. 62. — Plan of Heating System for Foundry.

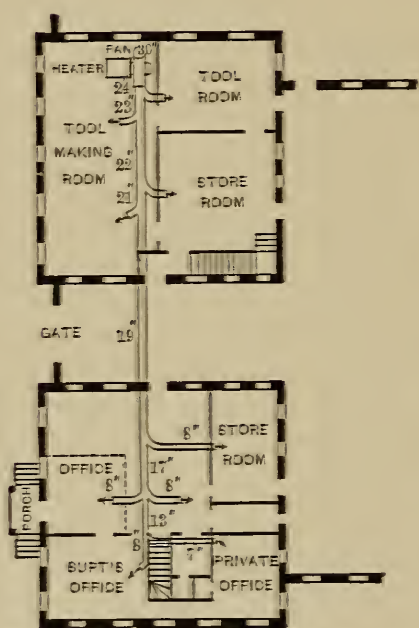


Fig. 63. — Plan of Heating System for Office Building. First Floor.

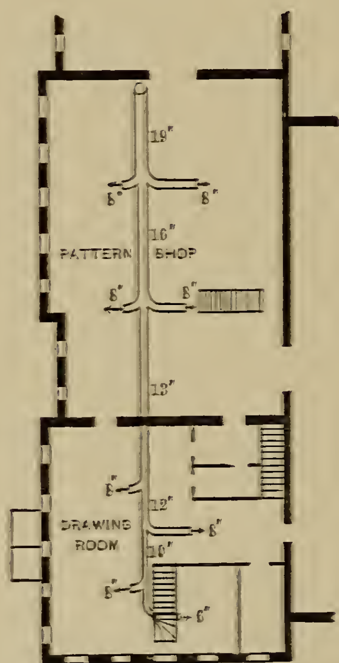


Fig. 64. — Plan of Heating System for Office Building. Second Floor.

The system of piping is clearly shown in the illustration and needs little explanation. The main pipe passing through over the driveway must be amply protected, preferably by being encased in a wooden box several inches larger than itself, the space being filled with sawdust or similar material; and

this again is covered by another box large enough to leave an air space of about three inches between the two, on all sides.

For the office rooms the pipes may be of rectangular form, concealed by suitable architectural finish of the ceiling, in which lateral openings for registers may be made. Or, proper air ducts may be formed in the side walls and the registers placed at suitable intervals. Or, again, the pipes may be carried around inside the walls, close to the ceilings, and registers located in the same manner.

There may be for this system the double-duct arrangement. That is,

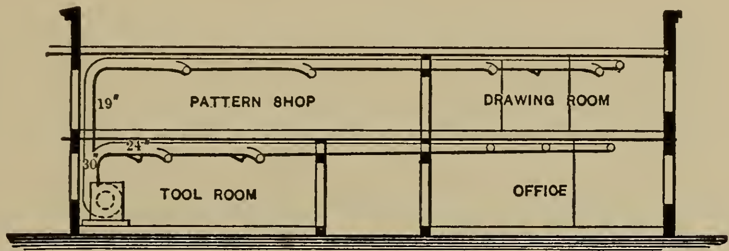


Fig. 65. — Longitudinal Section through Office Building.

two sets of pipes or ducts, one carrying cold and one warm air, the registers being so arranged that they will furnish one or the other, or a mixture of both, by means of what is technically known as a "mixing damper."

In offices and rooms of moderate size which are heated by warm air being forced into them near the ceiling, it is usual to provide means of escape for the air as it cools and descends to the floor, through grated openings placed two or three feet from the floor, and connected with flues or ducts leading to the roof. But in offices where doors are frequently opened this does not seem to be necessary, the matter of ventilation being of small consequence compared to that of heating.

The forge shop and various other buildings require no special arrangements for heating. The water-closet rooms may be warmed sufficiently by providing grated openings in the wall dividing them from the boiler room. They should be near the ceiling, on each floor.

The question of proper temperature of shops where men are at active work should be considered as quite different from providing for heating a factory where the work is usually much lighter, the number of employees per hundred feet of floor space much greater, and frequently a large proportion of them females.

In a machine shop devoted to a medium class of work, a temperature of about 60 degrees will be found generally comfortable to the majority of the men. We have known of shops where the temperature seldom went above 50 degrees in cold weather, and there was no complaint. The former figure will, however, be more satisfactory.

The temperature in the storeroom, tool room, and pattern shop will need to be about 65 degrees, and in the drawing room and offices, between this and 70 degrees. Unless the ventilation is very carefully attended to, there is more danger in having these latter rooms too warm than not warm enough, and any system of heating which does not recognize the importance of good and thorough ventilation is radically wrong in both theory and practice.

CHAPTER XIII

THE SYSTEM OF LIGHTING

Natural and artificial lighting. Forms and proportions of windows. Different kinds of glass. Position of windows. Diagrams illustrating various forms of lighting. The width of windows. Benedict's system of window construction, with illustrations. The good features of the plan. Skylights. Translucent substitute for glass. Shades and curtains. Artificial light. The hours of lighting by artificial light. Systems of artificial light. Electricity the most useful. Some of the old-time methods of lighting. To have light we must submit to heat. Arc lights versus incandescent lights. Advantages and disadvantages. Portable electric lights. Both arc and incandescent lights should be used. The dynamos. Distribution of lights. In the machine shop. The traveling crane space must be left unobstructed. In the galleries. In the foundry. In the forge shop. In the storehouse and carpenter shop. In the engine room. Arc lights in the yard. In the office building. Number of lights for the entire plant. Power necessary to supply the current. General arrangement shown in the plans.

The heating and ventilation of our manufacturing buildings having been duly provided for in the last chapter, the next question of importance to be considered is that of lighting, which forms the subject of the present chapter.

In considering the matter of lighting manufacturing buildings we may properly divide the subject into two parts. The first of these relates to the utilization and management of the sunlight for our use during the daytime; and the second, to the artificial light which we must provide in the absence of sunlight and in the dark and obscure corners, of which there should be as few as possible in the modern shop.

For properly lighting a shop during the daytime, many forms and proportions of windows have been devised, from those of small area and diminutive lights of glass, to those very high and narrow; those broad and low; those of large area placed far apart; those of much less area placed near together; those covering almost the entire wall with glass area; those placed vertical and those in an inclined position; those placed as skylights in the roof; and those placed in the ventilating space at the top or ridge of the roof.

Again, as to the kind and quality of glass used. Some prefer the ordinary plain glass, admitting a flood of light, regulating it by means of shades or curtains. Others use the same glass, "stippling" the surface with white zinc thinned with spirits of turpentine to relieve the eyes of the glaring light. Again,

ground glass is used. Still others prefer the rough cast or "cathedral" glass, as it is sometimes called.

What is called "ribbed glass," with the ribs or ridges running in a horizontal direction, is probably better than either. One inventor proposes to construct windows composed of a series of round rods of glass placed closely together, and states that one of its advantages is that if broken by a flying chip, or in any similar manner, only one or at most a few of the rods will be injured, and these may be easily and cheaply replaced.

In reviewing these various methods of construction it may be said that broad and low windows in the side walls will light the bench at the wall and perhaps one or two rows of machines, while the center of the room receives little or no illumination. This condition is sometimes sought to be remedied by the use of skylights in the roof.

Windows placed too high in the side walls will light the center of the room but leave the benches around the walls in the shadows of the high window sills. Therefore it is proper to so locate the window sill as to afford proper light at the bench vises; then to continue the window well up to the ceiling in order that the whole room may receive, as nearly as may be, an equal quantity of light.

In order that one may get a clear idea of the difference in the capacity of the various heights, positions, and angles of windows, several diagrams are presented to illustrate the matter.

Fig. 66 shows a cross-section of wall with the work bench in proper position, and the room lighted with one of the older styles of windows, which were

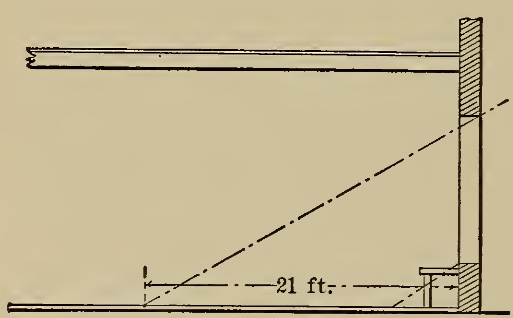


Fig. 66.— Lighting Diagram. Low Windows.

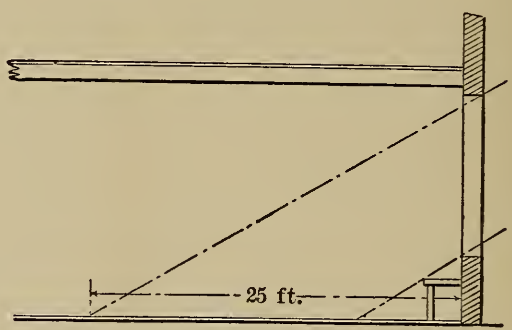


Fig. 67.— Lighting Diagram. High Windows.

placed considerably lower than is now the practice. It will be noticed that the rays of light entering at an angle of 30 degrees, the highest beam of light will touch the floor at a distance of 21 feet.

Fig. 67 shows a similar cross-section with the window placed high up, and it will be seen that the distance reached by the light is 25 feet, or about 20 per cent farther. At the same time the work which the machinist is doing at the bench is properly illuminated.

Fig. 68 shows a cross-section through the machine shop, and gives the

floor surfaces illuminated by parallel beams of light at various angles. It should be understood, of course, that in all these cases light is not confined to these surfaces, since it is always more or less strongly diffused over a much larger space. These diagrams are only intended to show the *relative* amount of illumination.

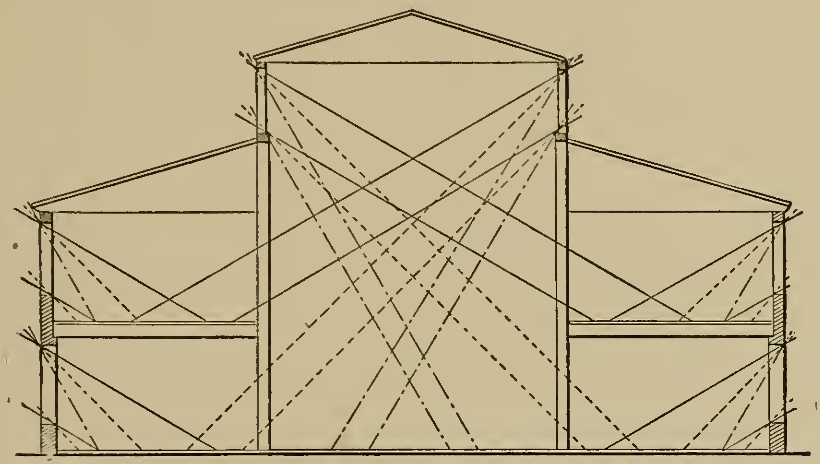


FIG. 68. — Lighting Diagram. Section through the Machine Shop.

Fig. 69 is a cross-section of the newer form of saw-tooth roof construction, and illustrates the largely increased amount of surface lighted up by this method, which is now generally regarded as the best method of lighting up large areas in one-story shops. In this system of lighting the windows should face towards the north.

The width of the windows and their distance apart is a matter of great difference of opinion. Where the construction is of steel or wood they may be placed less than two feet apart, if it seems necessary to do this. Where brick walls are used the distance should generally be more, depending, of course, on the entire height of the wall.

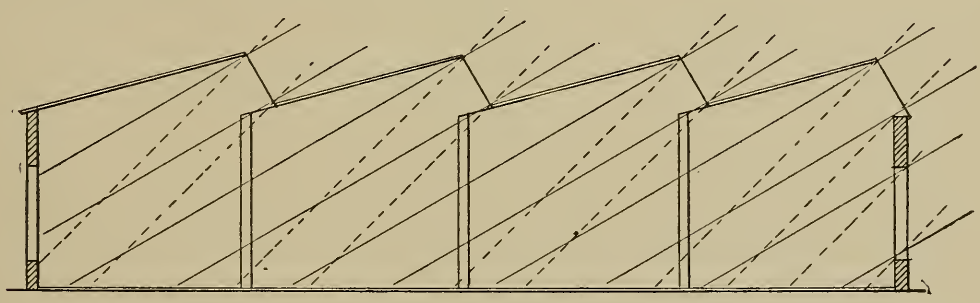


FIG. 69. — Lighting Diagram. The Saw-tooth Construction of Roof.

In our arrangement of the windows in the machine shop (as given in Chapter II) the size is 4 feet wide and 10 feet high. These figures are the dimensions of the inside of the sashes, therefore providing 40 square feet of glass. This will make the opening in the wall nearly 5 feet wide, which, with bays of 18 feet 3 inches centers, two windows to each bay, will give about 4 feet 2 inches of brickwork between the windows. This will give sufficient

strength to the side walls, and will also provide quite enough light for all ordinary classes of machine shop work to be done in such a building.

In reference to the details of construction of the windows of machine shops and factory buildings, Mr. Edwy E. Benedict, of Waterbury, Conn., a successful designer of factory buildings, has adopted the plan of having in each window three sashes, each containing two lights of glass. In the case illustrated they are of 24 x 24 glass, making a window of 4 x 6 feet, as shown in front elevation in Fig. 70. An outside elevation of the upper portion is shown in Fig. 71; a horizontal section of one jamb, with sash, glass, weather strips, etc., in Fig. 72; an inside elevation, showing the inside finish at the top and bottom, in Fig. 73; and a vertical cross-section in Fig. 74.

Fig. 70.— Outside Elevation of Benedict's Shop Window.

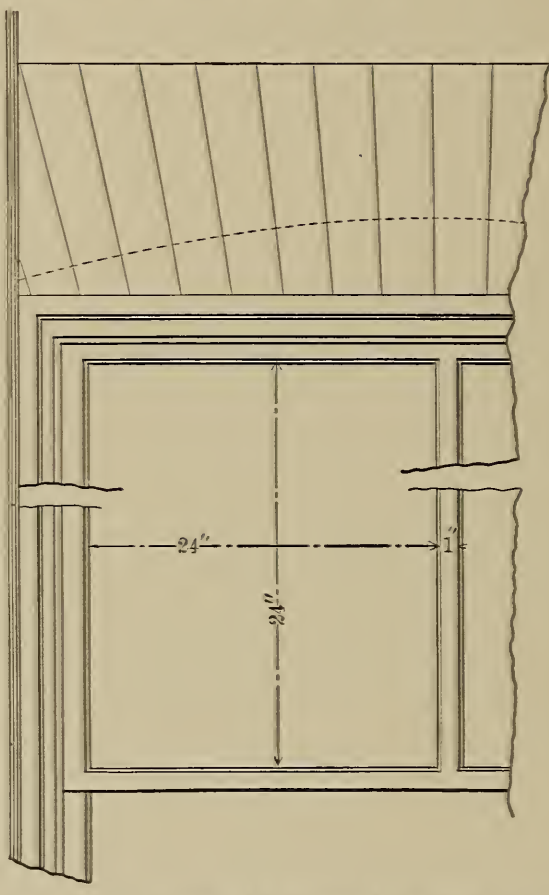


Fig. 71.— Outside Elevation of upper portion.

Some of the good features of this plan will, no doubt, be heartily commended by practical men. For instance, in Fig. 71 it will be noticed that the flat arch on the outside face of the wall reaches down below the segment, or supporting arch, which is shown in dotted lines in this figure, and drawn in full lines in Fig. 73. The vertical section in Fig. 78 shows its office, of making the top of the window weather-tight. It will also be noticed, by reference to Fig. 72, that the side face casings are built into the brick wall for the same purpose. These points, with the use of the Tabor weather strips, make a perfectly weather-tight arrangement that will be greatly appreciated by the

workmen in the shop, as well as the man who pays the coal bills. The working details are quite clearly shown in the several views.

Windows may be made of any desired height by increasing the length of the lights of glass. Thus, 24 x 36 glass would make a window 4 by 9 feet.

The bottom sash is glazed with clear glass, and the two above it with ribbed glass, the ribs running horizontal in all cases.

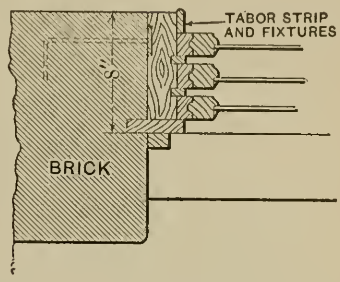


Fig. 72.—Horizontal Section of Window jamb, sash, glass, etc.

Skylights should not be used where they can be avoided, as they are a prolific source of leaky roofs, damage by accidental breakage, as well as numerous other difficulties, and even a light fall of snow quite destroys their lighting properties.

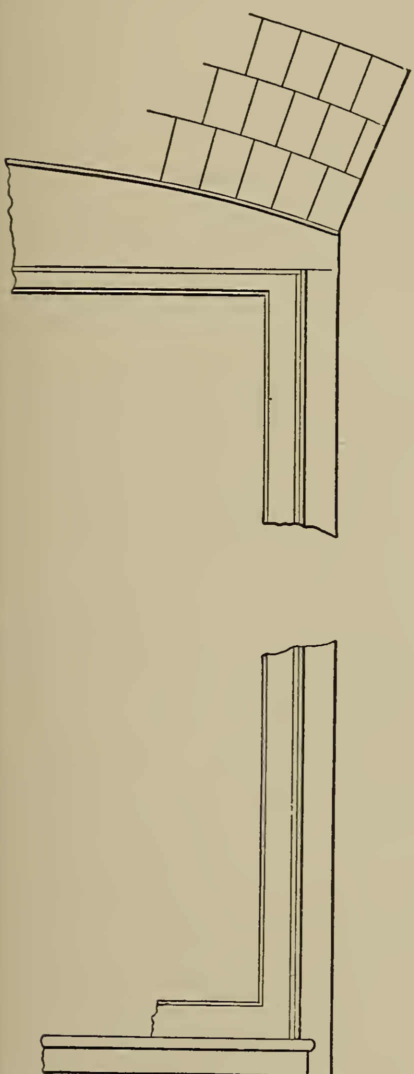


Fig. 73.—Inside Elevation, showing inside finish.

A translucent material formed on a fine wire netting is an excellent substitute for glass where skylights must be used. It gives a soft, diffused light and there is no danger of breakage as with glass. Windows in the ventilating portion of the roof are not only useful for lighting the central portion of the shop, but they conveniently act as ventilators when the sashes are hung on pivots and handled by cords. They may easily be so constructed as to avoid any trouble from leaking.

As to the kind of glass to be used, the plain glass is, of course, the cheapest. It must, however, be shaded by curtains, which can be readily run up and down; and these are liable to get out of order and to require a continual expense to keep them in presentable and useful condition. The amount thus spent added to the cost of plain glass will soon pay for good ground glass which will need no curtains, and which, while rendering the light soft and agreeable to the eyes of the workmen, will also diffuse it over the area of the shop much better and more equally than the plain glass. At the same time none of the light is lost by interposed shades or curtains.

As to "stippled" glass, the stipple is apt to crack and peal off, and will also absorb considerable dirt and grease, making it much more difficult to

keep clean than clear or ground glass; and the repeated washings are apt to remove portions of the "stippling," leaving a patched and unsightly effect. The rough or "cathedral" glass is more expensive, not as agreeable to the eyes, and considerably lessens the volume of light. Windows of glass rods do not seem to have been sufficiently employed to demonstrate their usefulness. Ribbed glass is now quite popular for shop windows and diffuses a soft and agreeable light, and seems best adapted for the purpose.

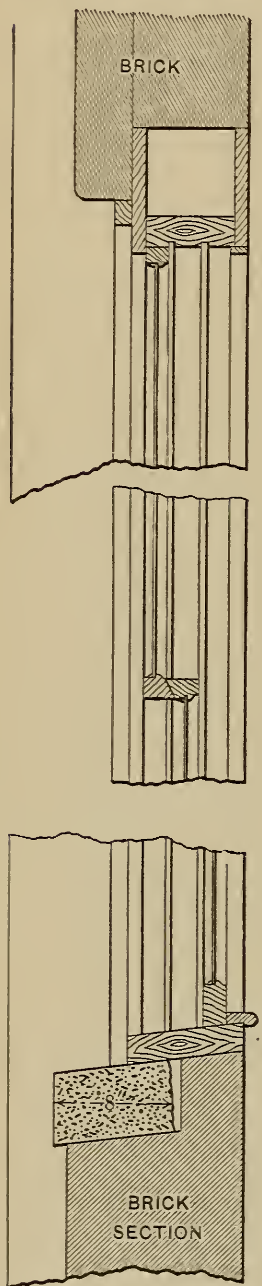


Fig. 74. — Vertical Cross Section.

We have seen shops in which practically the whole side wall was a mass of glass, only the space for the posts supporting the roof and the frames containing the sashes being opaque. Such a prodigality of light does not seem necessary in practice, and in fact it may be hurtful to the eyesight of the workmen, while the cost of construction and the continual cost of renewals and repairs of such a great quantity of glass will be a large initial expense as well as an important annual outlay. The expense of heating will also be largely increased.

Let us now consider the question of artificial light. First, the usual time during which we must provide for artificially lighting up the buildings. Omitting the six usual holidays of the year and calculating on the basis of a ten-hour day, we have 3,060 working hours in a year's work. If the working day begins at 7 A. M. and ends at 6 P. M., with one hour for dinner, we shall need artificial light, for the ordinarily well-lighted shops, for about 460 hours out of the entire 3,060 working hours of the year.

This will include "lighting-up time" divided among the different months as follows: January, 102 hours; February, 60 hours; March, 32 hours; May, 8 hours; June and July, none; August, 8 hours; September, 20 hours; October, 50 hours; November, 78 hours; and December, 102 hours.

To properly provide for sufficient lighting during these periods we must select some one of the many systems in use, and the one which seems best adapted to the conditions of the case. Whatever may be the future development, either as to perfecting and simplifying its application, extending its sphere of usefulness, or reducing its cost, electricity at present stands at the head, when the question of a perfect light, or at least the most available one, is considered, for the illumination of nearly

all classes of large buildings, particularly such as are used for manufacturing purposes.

Still there seem to be indications that there may be yet other systems of artificial lighting which by development may become dangerous rivals of the popular systems of electric lighting — acetylene gas, for instance. This method is still in the infancy of its development and use, and there seem very few of the usual difficulties to be overcome excepting the danger of its explosion in the hands of inexperienced persons. This difficulty will probably be overcome in time and the use of it be as safe, both to generate and to manage, as electricity.

It is also true that the system of electric lighting has many fatal accidents charged against it. These may all have been due to improperly constructed apparatus, the careless management of it, or the imperfect knowledge of its properties and action. The same may be said of acetylene gas.

That we have yet attained to the perfect artificial light no one will have the courage to assert, since improvements are continually in progress in this direction, but at present we must be satisfied with electricity, with gas as a supplementary light when the electric current is not available.

To provide an ample, proper, safe, and thorough system of illumination for buildings in which a large number of persons are obliged to labor for so many hours each year by its aid, would seem to be a matter that need not be argued or advocated. Yet there are many shops at the present time so constructed that some kind of an artificial light is needed all through the day, and in some at nearly all seasons of the year, and this condition prevails over a considerable part of the working space.

The result must necessarily be that both the quantity and the quality of the work done is below the standard, while the health and the eyesight of the employees are both unnecessarily impaired, since sunlight and fresh air are two very important elements necessary to the health, activity, and usefulness of the human family. Ofttimes the evil results from a lack of consideration or appreciation of these necessities, and sometimes perhaps from a false idea of economy on the part of those having charge of such matters, which has led them to provide very indifferent substitutes for sunlight, or, in its absence, a proper artificial light.

For it is true, "and pity 'tis, 'tis true," that in some shops, even in this enlightened age, many hours' work is done by the smoky glimmer of dirty oil lamps, these relics of a bygone age, since they are not many steps in advance of the vessels of oil with their fibrous wicks resting against one side, used in the days of Abraham, 1920 B.C.

Although the common use of petroleum oils in various degrees of refining have revolutionized the old-time lamp, and the simplifying of the processes for

generating and purifying illuminating gas have produced two very useful illuminants within the reach of nearly every one, they will probably never regain the position which they lost when the practical utility of electric lighting became a recognized fact.

The one great drawback to all artificial means of illumination is that to produce light we must generate heat; and hence, however we produce light, whether by the combustion of oil or gas, or by the generation of an electric current, to form a brilliant arc, or a glowing incandescence, we must necessarily waste a large percentage of energy in producing heat which we do not want and which is often a very serious objection.

We shall therefore not have the perfect light until we have been able to produce the illumination we desire without generating heat. Whether we shall ever realize that much-sought condition is a question for future development and invention to demonstrate.

In the application of the electric light in manufacturing operations we have the choice of the arc lamp and the incandescent lamp. Both have their objections as well as their merits. The arc lamp, being much more powerful and projecting its rays a much greater distance than the incandescent lamp, is well adapted to illuminating large areas, where there are comparatively few obstructions. In confined situations, or where there are many obstructions, it produces disagreeable shadows, and its glaring brilliancy is hurtful to the eyesight of the workmen.

Translucent globes or shades may be used, of course, but these devices necessarily reduce the illuminating power of the lamp. Again, the arc lamp is not readily moved from place to place, even short distances, so that the workmen must often stand literally "in his own light."

The incandescent lamp gives a much softer and more agreeable light to the eyes of the workmen, who may work many hours by its aid with less discomfort than by almost any other light. It is also much more portable than the arc lamp, since it may be provided with flexible conducting cords of any convenient length, and hung up or held in the hand in the most desirable positions.

Still another convenience of the incandescent lamp is that of being able to locate a magnet in the base of it, by which means the lamp is retained in any desired position by simply placing it against any iron or steel surface. This is a matter of great convenience when working in dark corners or making repairs under machines, where the usual fixed lights are of little use and where ordinary incandescent lamps must be held in the hand; and also in awkward positions such as are frequently found during the work of erecting heavy machinery or repairing it.

These convenient characteristics of the incandescent lamp render it

valuable for practical use in the machine shop. It may be readily placed in confined situations where an arc light could not, and it may be used much nearer the eyes of the workman without injury.

It would therefore seem wise, in devising a system of artificial lighting, to avail ourselves of the advantages offered by both the arc and the incandescent lamps, each in the places where their special merits can be made use of. Both types of lamps may be operated by the current from one dynamo, by the use of proper transformers, but it will usually be found more practical to put in a dynamo specially designed for each system.

More recently a light has been produced by the action of an electric current upon mercury confined in a glass tube two feet or more in length. A peculiarity of this light is to render yellow tints more pronounced and giving a peculiar green tint to many objects.

Ample space has been provided in the engine room for dynamos for this purpose, as well as for furnishing the necessary current for operating the traveling crane in the machine shop and the power required in the foundry.

In the machine shop the clear space needed for the traveling crane precludes the suspending of arc lamps through this central portion, but they may be placed between and a little inside of the line of the columns. They should be about 50 feet apart, which would require 14 lamps on the main floor. In addition to these a sufficient number of incandescent lamps should be provided to accommodate the individual needs of the men operating machines, wherever such additional illumination is necessary from the location of the machines and the character of the work.

They should also be provided at the small tool-distributing room and in the foremen's offices, and a number should also be hung upon the columns, having sufficient length of conductor cord attached to them so that they may be used in erecting machines in the central space.

From the character of the machines employed and the work done in the galleries the incandescent lamp will be the most suitable. There should be at least one to each machine and in the case of long lathes one to every ten or twelve feet of bed. A lamp should also be hung at the head of each stairway.

The large open space of the foundry may well be provided with arc lamps, four of which will be sufficient, supplemented by a few incandescent lamps with long cords hung on the columns, for use in deep molds and similar places left in darkness by the arc-light shadows.

The chipping and pickling room will require one arc lamp and several incandescent lamps, all provided with wire nettings for protecting them from flying chips. The core room, wash room, foreman's office, water-closets, the space under the cupola platform, etc., will require incandescent lamps.

The forge shop will be best served by two arc lights in the main part,

and by incandescent lamps in the foreman's office, wash rooms, water-closets and perhaps in the bar stock storage space.

One arc lamp in the storehouse and one in the carpenter shop, with perhaps two or three incandescent lamps in the latter, will be sufficient.

The boiler room will require an arc lamp hung over the tram track so as to fully illuminate the boiler fronts, and two or three incandescent lamps convenient to the space in the rear of the boilers and in similar places. The same number and kind of lamps will answer for the engine room. The adjoining wash rooms and water-closets should be provided with incandescent lamps, say four in each of the former and three in each of the latter.

An arc lamp erected on a pole 20 feet high should be located in the yard between the foundry and the power house and about 35 feet from the machine shop. A similar one should be placed in the center of the space between the storage sheds, carpenter shop, power house, and the forge shop. These will greatly facilitate yard work near the close of the short winter days.

The entire front building, including the offices, tool rooms, pattern shop, pattern storage loft, drawing room, etc., should be lighted by incandescent lamps, those in each room being arranged to suit the peculiar conditions in each case, as to the kind of shades and reflectors employed.

To equip the entire plant as described above will require say 27 arc lamps and 267 incandescent lamps, the latter number being somewhat lessened or considerably increased according to the character of the machinery to be manufactured, as whatever change in this respect is made would most likely affect the incandescent lamps and possibly the arc lamps as well.

In providing for the amount of current necessary to supply this system of lighting we should make allowance for any possible increase that may be called for by unforeseeen circumstancs, or by a change in the products of the concern, and it would usually be safe to add for this purpose at least 10 per cent.

The power necessary to run the dynamos with the added 10 per cent will be about 30 horse-power for the arc lamps and 20 horse-power for the incandescent lamps, or a total of say 50 horse-power to be provided for, in calculating the capacity of the proposed engines.

By referring to the general plan drawing given in Chapter II, the arrangement of the lamps as herein described may be readily understood.

CHAPTER XIV

POWER AND TRANSMISSION

It is ofttimes a complex subject. The different systems. Steam is at the head. Electricity. Compressed air. Transmission of power. Various systems. Belts. Ropes. Chains. All systems are merely that of transmitting power. Water and steam are our original sources of power. The systems of transmission, or distribution of power. The boiler room. Types of boilers. The best type. Mechanical stoking. Boiler settings. Longitudinal section. Cross-section. Horizontal section. Smoke connections. Steam connections. Foundations for boiler settings. Gas engines. Steam engines. Transmission by belts and shafts, or by electric motors. Compressed air for foundry and forge shop. Compressed air in the machine shop. Motors for individual machines. The system adopted. Lighting dynamos. Driving the steam hammer in the forge shop. Boiler and pipe coverings.

In considering the question of power and its transmission to the different points in the plant where it will be required, we are confronted by a rather complex subject, and one which has been much discussed by many competent engineers in nearly all the mechanical journals during the past few years. Steam is now, and for probably an indefinite time will be, the favorite and controlling power generator, since to it we owe all other forms, not of power, but of the transmission of power. The various methods and theories have had able champions in the special line in which they have been interested, and rival claims have been ingeniously advocated to prove that they were the best methods to be adopted for nearly all conditions.

One class have proven, to their own satisfaction at least, that while electricity is still in a very imperfect state of development and generally very imperfectly understood by a large majority of mechanics, it is to be the coming power for all purposes and may be used under nearly all conditions. Many of these claims have been well substantiated and the fact is that to-day there is a far greater and more general use of electricity in transmitting power than was thought possible even ten years ago. The ultimate limit to its usefulness no one can foresee.

Again, the advocates of compressed air have shown that this has many advantages as an easily transmitted and very useful power, and in its special sphere is doing very efficient and admirable work. New applications are

constantly being found for it, and many operations formerly performed by hand are very much quicker, cheaper, and better accomplished by its use. The sphere of its usefulness has broadened very much in the last few years and now we find it in nearly all up-to-date shops, for a large variety of purposes. In this it does not take the place of electricity, but rather is used in conjunction with it, or with steam power for the purpose of providing the compressed air, as may be most convenient.

The old-time mechanic is, however, apt to "pin his faith" to shafting and belts as the most reliable method of transmitting power, perhaps because he is better acquainted with this method; while the younger men are prone to argue the efficiency of rope transmission as the proper method. Many examples of efficient service by rope transmission might be cited, yet for the general purposes of a machine shop it is doubtful if it will ever replace leather belting altogether.

Recently the utility of transmission by chain has been revived and the interest in the subject very much increased by the improved forms adopted by later inventors. It is often exceedingly useful for the transmission of power within the limits of a single machine, formerly for operating feeds, and later for transmitting the principal power of the machine. Properly constructed, this system would seem to have a broad and practical field of usefulness in the future.

But all of these methods and systems, when reduced to the plane of practice in providing for the power plant of manufacturing concerns, are simply so many different methods of transmitting and distributing power, since it is to water or steam that we must look for our original power. We are confined, then, to these two sources of power — water and steam — and where the location does not provide us water power we must accept steam. Assuming the latter conditions in our manufacturing plant we must provide for steam as our source of power.

This having been settled, the best means of transmitting the power to the machines on the ground floor of the machine shop, to those on the gallery floors, to those in the tool room and pattern shop, and to the forge shop, foundry, and carpenter shop, must also be considered.

The question of boilers will naturally come first, and, in this connection, the type best adapted to the work; also the best method of setting them to produce the most efficient results. Next, the type and the dimensions of the engine, and the manner of its connections. And lastly, the method of transmitting the power to the machines to be driven.

In arranging our power plant we begin with the boiler room. We shall need a working capacity of at least 500 horse-power. This may be distributed in a battery of boilers of 100 horse-power each. One extra boiler is added so

that in case of an accident to one of them, necessitating repairs, five of them may still be in proper working condition. Four of these boilers will be needed to run the engine, which leaves a margin of 100 horse-power with which to supply the necessary steam for other purposes about the plant.

Under ordinary conditions a sixth boiler may be added, giving 200 horse-power for these purposes. By this arrangement there is the additional advantage that the boilers may be cleaned one at a time without shutting down the power.

The styles and types of boilers in the market are many and various, and most of them have good and practical claims to consideration in one way or another. But it is somewhat doubtful if any type will be devised that will become as popular for general use — or in the long run any more efficient and economical for hard, every-day service — as the return tubular type.

Ofttimes the space in which the boilers must be located will determine the type, whether they shall be upright or horizontal; and the method of firing them, as well as the kind of fuel to be used, must also be taken into consideration.

Mechanical stoking is used with success in some instances, but as yet has not come into general use. Both oil and natural gas as a fuel are much used in such localities as render them more economical than coal.

Our boilers will therefore be of the return tubular type, fired by hand, with the usual kind of soft or bituminous coal. They will be 66 inches diameter and 16 feet long, exclusive of the curtain sheet under the space occupied by the "up-take," or smoke connection.

The arrangement for setting the boilers is shown in vertical, longitudinal section in Fig. 75; in a half vertical cross-section, and half front elevation in Fig. 76, and in a horizontal section above the grate line in Fig. 77.

There are several matters in connection with the setting of boilers which should be strictly attended to. Among these are the following: Two courses of bricks should be laid above the floor line of the boiler room for the boiler fronts to rest upon; the top course at least should be headers, and carefully leveled up. They should be so located that at least two inches will project in front of the boiler fronts. The ashpits should be cemented so as to allow of the introduction of a few inches of water.

The front supporting brackets should rest fairly upon iron plates in the side walls, while the rear brackets rest on rollers, which in turn rest on the iron plates set in the walls, by which arrangement all expansion of the boiler is toward the rear. The brickwork around the brackets should be entirely clear of them so as to leave the boilers opportunity to expand and contract without injury to the walls.

The grates should incline from front to back from $\frac{1}{4}$ to $\frac{3}{4}$ inch per foot.

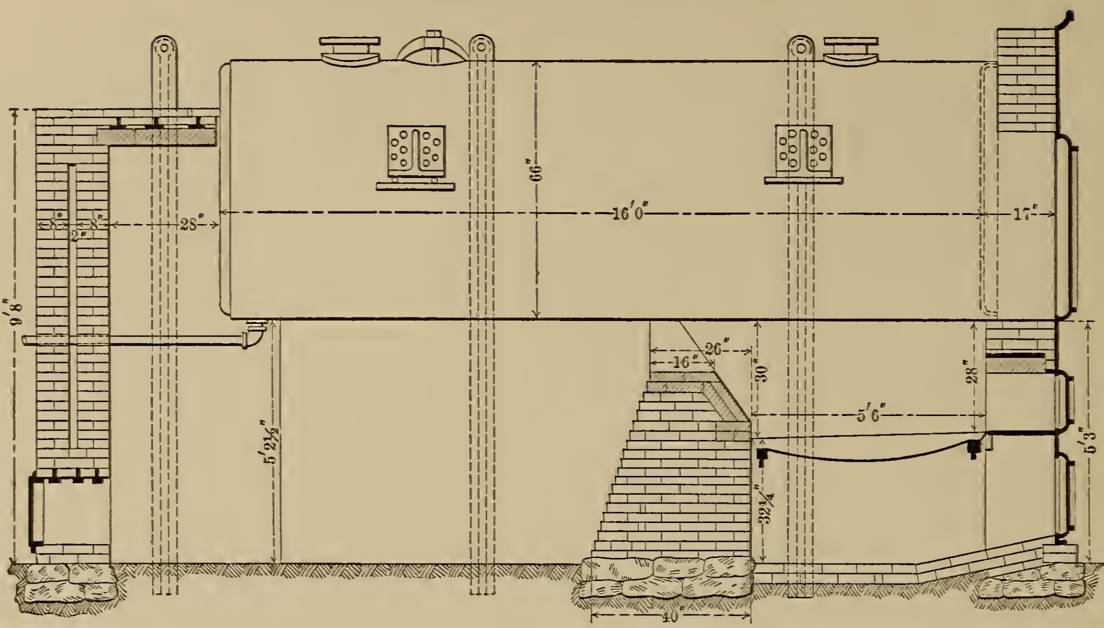


Fig. 75. — Longitudinal Section of Boiler Setting.

The bridge wall should come up to within 12 or 14 inches of the bottom of the boiler, and be curved to suit its form, although this is not absolutely necessary. The width of grate surface should be equal to the diameter of the boiler.

The side walls of the furnace are to incline outwards, so as to be two inches from the sides of the boiler, at a point one course of bricks below the bottom of the brackets. The fire bricks should be laid with a header course every five courses, so that burned-out bricks may be conveniently replaced.

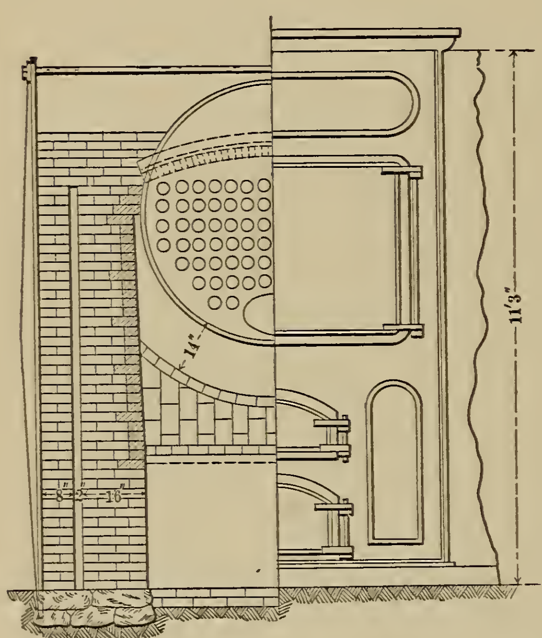


Fig. 76. — Vertical Half Cross Section and Elevation of Boiler Setting.

At each side of the fire doors cast iron "cheek-pieces" should be put in, the cast iron arch plate over the door resting on them. These "cheek-pieces" should be about $1\frac{1}{4}$ inches thick, of the form shown in Fig. 77, and have as many half-inch holes cored in them as possible, the holes spaced two inches from center to center, for an air supply to prevent them from burning out. Their height is equal to the height of the fire door at the side. They will be found to be very durable and to save much expense in fire brick repairs.

They may be removed and replaced whenever the furnace is cool, by jacking up the arch plate a trifle and letting it down on the new "cheek-piece"

introduced. Their inclined form renders the cleaning of the fire much more convenient and the extreme front corner which they cut off is of little benefit in making steam.

Both outside and division walls should have a two-inch air space, as shown. The top of the boiler should be covered with asbestos, or with a brick arch. If the latter, there should be a two-inch air space left between it and the boiler. The boilers must rest only on the supporting brackets and in no case on the boiler fronts.

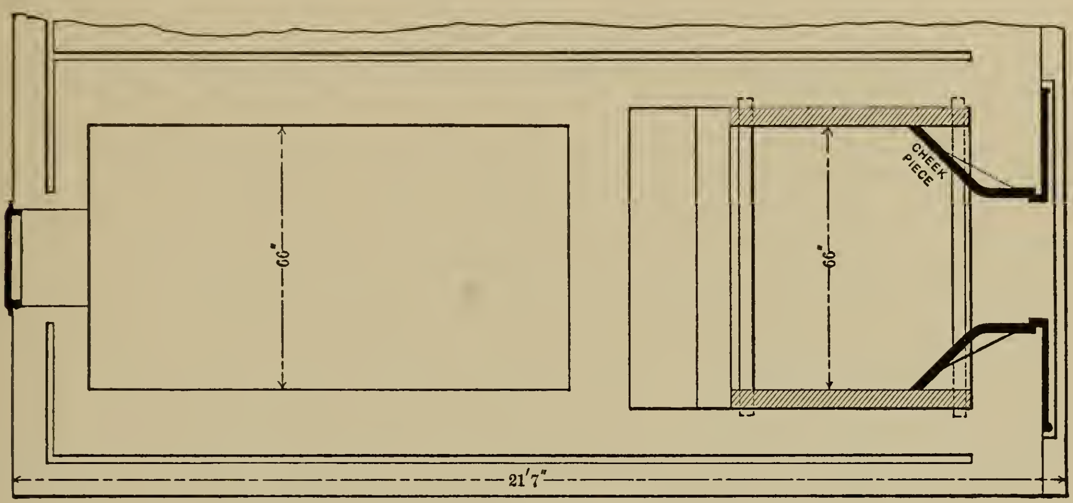


FIG. 77.—Horizontal Section of Boiler Setting.

The fronts are held in place by anchor bolts $\frac{3}{4}$ inch in diameter and 4 feet long, with the inner ends bent to a right angle 10 or 12 inches long. Their front ends are threaded for nuts coming outside of the boiler fronts, so that a defective or cracked portion of the front may be readily removed and replaced without disturbing the brickwork.

The smoke connections from the boilers to the stack may be the same width all the way through, in which case its height is to be increased from the first to the sixth boiler to include the additional area necessary for each boiler as it progresses toward the stack. Thus it may be 36 inches wide and 20 inches high at the first boiler, and increasing to 78 inches high at the sixth boiler. It will perhaps be more convenient to increase also the width, in order that the area at the large end may equal that of the stack without increasing the height to such an extent.

By this method we may make the larger end 48 inches wide and 60 inches high. There should be a cleaning door in the end of the smoke connection at the first boiler, and a pivoted damper properly balanced between the sixth boiler and the stack. It will be convenient also to have dampers in the "up-take" from each boiler to the main smoke connection, so as to shut these off whenever a boiler is laid off for cleaning or repairs.

The steam connections from the tops of the boilers are to be so arranged

that any one or more of the boilers may be "cut out" and the use of all the others continued. All steam pipes of three inches or over should be covered with an efficient and lasting non-conducting material. That containing a large portion of asbestos will probably be found the best.

The foundations for the boiler settings should be prepared in the same manner as for a machine foundation, as described in Chapter X, due consideration being given to the weight to be supported, say about 1,200 pounds per square foot.

The plan of boiler settings shown, that is, supporting the boiler on brackets attached to it, is the ordinary method. The more modern method, however, is to erect iron columns at each side of the boiler and upon these to lay I-beams, from which the boiler is suspended by iron rods, entirely clear of the brickwork, and with no part resting upon it. While this plan is no doubt correct in theory and practice, it is considerably more expensive than the method shown herewith and for that reason it may not receive the favor it deserves.

The general plan and arrangement of the boiler room with the boiler settings, the smoke connections with the stack, the coal-delivering tram track, scales, etc., and the engine room, with the location of the engine and its connection with the main shaft, is shown in Fig. 78, and in so far as it relates to the boilers and settings it is substantially the system adopted by the Bigelow Company, New Haven, Conn.

As to the engine, it seems fairly well conceded that for economy of steam and general efficiency in furnishing the power for machine shop work the horizontal, cross compound condensing engine will be the best. This type of engine is made by a number of well-known engine builders, and while all of them have certain convenient features and peculiarities of design and construction which commend them to different purchasers, it is probable that there is no very great difference in their efficiency or economy in the general results.

The subject of gas engines has not been considered in connection with our plans as they do not seem suitable where a large amount of power is required, whatever may be their advantages in small or isolated plants, although gas engines have been built as large as a thousand horse-power that have been fairly successful.

Prominent among the builders of steam engines of the type referred to above are the Allis-Chalmers Company, of Milwaukee, Wis., and the William A. Harris Engine Company, of Providence, R. I., and it is this type of engine which is illustrated and described in this article, and commended for machine shop use.

The size selected may be 16 and 32 x 48 inches, or 18 and 36 x 42 inches, with a balance wheel 18 feet in diameter with a 36-inch face, and capable of

generating 400 horse-power at 80 revolutions per minute, and steam at 125 pounds pressure.

It will be proper to consider whether to drive direct from the engine to the machines by means of shafting and belts, or whether the engine shall drive dynamos, from which the electric current may be transmitted by proper

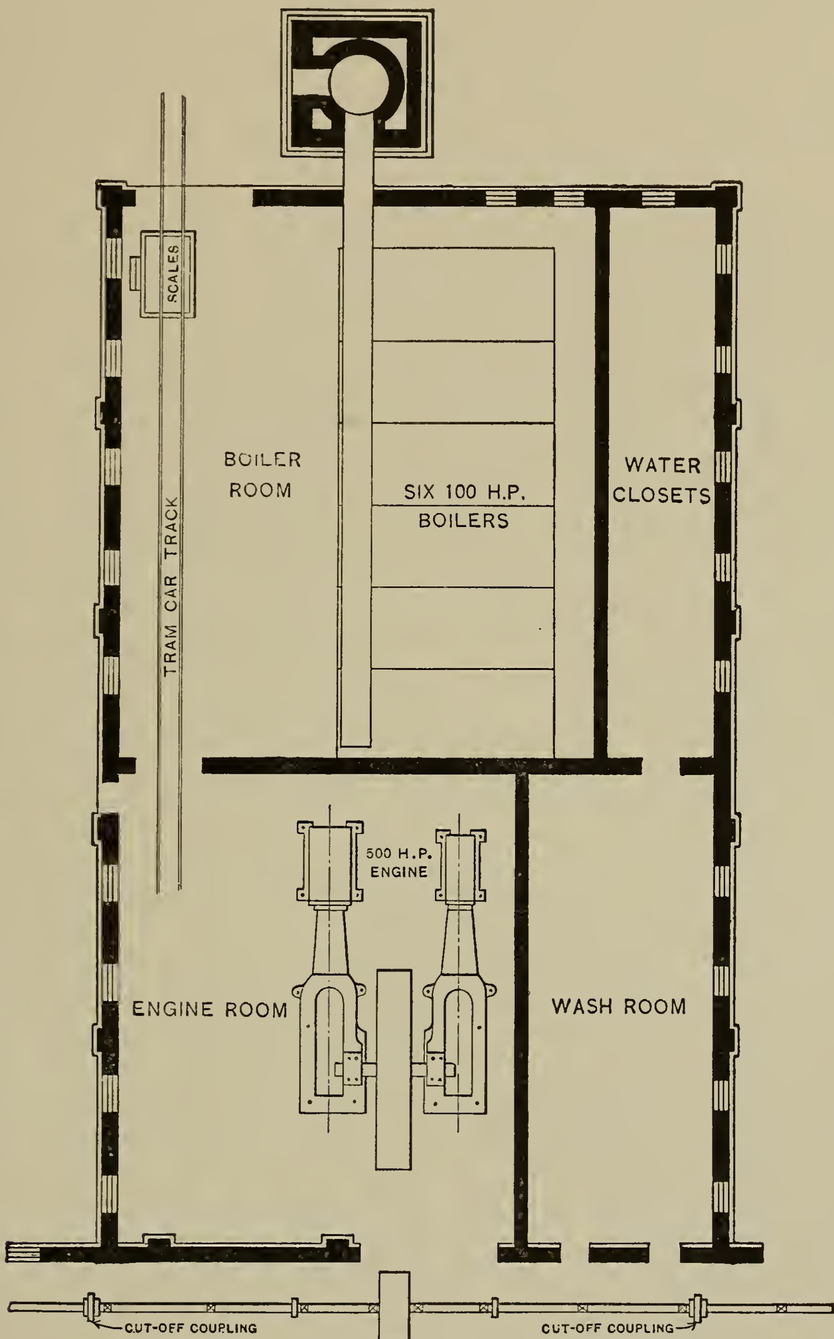


FIG. 78. — General Plan of the Power Plant.

conductors to motors, which in turn may drive main lines of shafting, or to a number of motors located in different parts of the works, driving short lines of shafting operating groups of machines, or again, whether we shall place a small motor upon each individual machine to drive it.

All of these methods have their peculiar advantages and necessarily their

disadvantages, corresponding to the conditions, the positions of the machines to be operated and the duty that is to be performed. Again, we may profitably make use of compressed air for some of our work, as for instance, for drawing patterns, turning flasks and other portions of the lighter work of the iron foundry, as well as for the chipping room where hand chipping tools so operated are very convenient and useful.

Hammers operated by compressed air may be used in the forge shop, since this force may be transmitted long distances with practically no loss such as steam is subjected to by condensation, and electricity by loss of electromotive force.

Various operations in the machine shop also may render a supply of compressed air very desirable. This matter will be governed to a considerable extent by the kind of work to be done, or kind of machinery to be built.

It would seem best in theory as well as practice, and most efficient and economical, to avail ourselves of whatever good points each method possesses for the particular case in question, and, by using any of the different systems where the conditions are most favorable for its employment, to make the most of the useful and practical features and avoid as many of the difficulties and disadvantages as we may be able.

For instance, while the practice of driving individual machines by separate motors may be said to be yet in its infancy, enough has been already done to prove its advisability in many ways, and to show that planers from 40 inches upwards may be profitably driven in this manner.

The same may be said of lathes from say 36 inches upwards, and also of the larger radial drills, vertical milling machines, boring mills, and, in fact, of most of the heavy machine shop tools. At the same time it does not appear to be as efficient or practical to apply individual motors to small machines when a group of them may be conveniently driven from a short line shaft run by one motor. The more recent improvements in motors, however, have adapted them to their economical use on much smaller machines even when a slow speed is required.

The question of friction of the two systems of transmitting power, that is, from the engine by shafting and belting, or the loss of power by generating an electric current with which to drive motors, is one which has provoked much discussion. Probably it will be found in practice to be about as follows: Where the distance is short, shafting and pulleys are much the more economical. For distances of two or three hundred feet there will be little difference in the two systems. For much greater distances the advantages are in favor of the electric method.

The plan of power transmission here selected is to drive from the balance wheel of the engine to a 72-inch pulley on the main line of shafting, giving a

shaft speed of 240 revolutions per minute. This shaft is in lengths of 20 feet, supported by hangers every 10 feet, and with a hanger on each side of main driving pulleys. The three lengths in the center are 5 inches in diameter and the remaining portion each way from these three lengths is $3\frac{1}{2}$ inches in diameter to the end.

Cut-off couplings are provided on the main shaft at the points shown in the drawings, for the purpose of stopping either section of the shaft in case of accident. In the same manner, the shaft in the gallery over the main line has a cut-off coupling at each end of the section, upon which the main pulley is located.

The smaller sizes of shafting are now usually made on the odd sixteenth of an inch diameter, but the even sizes are here given for convenience. The shafts are provided with roller bearings, and all pulleys with the exception of the large main driving pulleys are of the pressed sheet steel form, as being the lightest pulley made for strength, convenience, and transmission of power.

From the end of the main shaft toward the front of the building, power is taken for the machines in the tool room. From near the center, power is carried by a vertical belt to the gallery floor above. This shaft is $3\frac{1}{2}$ inches in diameter for the central 20-foot length and the remainder is 3 inches in diameter. Upon the central length, as well as on the main line below, are pulleys 48 inches in diameter and 14 inches face. The central length is supported by four hangers — one at each end, and one on each side of the main pulley.

In all cases the couplings are to be placed on the side of the hanger away from the source of power, so as to be secure in case of the failure of a coupling.

The dynamos for lighting as well as those for driving the motors may be located in the engine room and driven by belts from the main line by friction pulleys, or they may be located under the main line shafting.

It should be remembered that for a belt of high velocity it will be much better to run it horizontally than vertically, and that it will transmit much more power under the former condition. If it is desired to locate the dynamos in the engine room and run them by horizontal belts, a countershaft may be located near the floor, just inside the engine room and driven by a belt from the main line.

An independent engine may be used to drive the motors. In this case the power of the main engine would be considerably reduced. The main line shaft furnishes power for all machines on that side of the main floor.

The machines on the opposite side of the main floor may be those which it is desired to drive by individual motors, while in the gallery above, the line shaft, in say three or four sections, may be driven by suitable motors.

The same method may be desirable in the pattern shop and also in the tool room, if preferred, although it is more adaptable in the pattern shop where power is not used continuously.

The power for driving the machines in the carpenter shop may be transmitted by belt from the main line through a belt box occupying the space between the machine shop and the carpenter shop to the line shaft in the latter. Or, a motor may be located in the carpenter shop.

If a steam hammer is used in the forge shop the steam supply should be carried in a pipe passing through an underground brick conduit, as carrying it around through the machine shop and carpenter shop would necessitate a long line of piping.

A motor will be most convenient for operating the blast fan, drop hammers, cutting-off machines, power hack saws, etc.

For the foundry, steam may be carried under ground, across the yard in a brick conduit, as the most direct way, to the engine running the heating apparatus, and another for the cupola blower and the tumbling barrels. Here again motors will be very convenient, as one may be directly connected to the heating apparatus fan and another used for the cupola blower and the tumbling barrels, as well as to run the elevator which supplies the cupola platform with its fuel and stock.

The boilers, and at least all pipes over $1\frac{1}{2}$ inches in diameter, conveying live steam, should be protected with a good non-conducting covering. Probably the best preparation for this purpose is a mixture of carbonate of magnesia and asbestos, only a sufficient quantity of the latter being used as a bond, to hold the mixture together. The proportions may be, eight parts of magnesia and two parts of asbestos, with a sufficient quantity of water to form a plastic mass.

The thickness of this covering will depend on the amount of exposure to cold air to which the boilers or steam pipes are subjected. From one to two inches is ordinarily used, according to circumstances.

CHAPTER XV

SOME CONCLUDING REMARKS

The choice of ground for manufacturing plants. Important requisites. High fixed expenses of city locations. The quality of ground. Hard gravel the best. Drainage. Sewerage system. Grading the yards. Catch basins. Conductor piper and sewer connections. Makeshift devices. Cobblestone pavements. Foundation protection. Yard areas. Water-ways. Covering catch basins. Capacity of catch basins. General observations.

Before concluding this subject there are some remarks of a more or less general nature which seem proper to make here rather than in any of the preceding chapters, as they have each been assigned to a specific division of the subject, and the effort has been made to confine them to that portion of the question as nearly as may be, without restricting their scope within too narrow boundaries for practical use, and the consideration of practical men.

The choice of the ground upon which to erect manufacturing buildings is one which should receive mature consideration for a number of important reasons, and in this respect the following are some of the more obvious ones which should claim earnest attention. The ground chosen for the proposed plant should be situated near enough to a railroad so that a spur track may be laid to the works, for convenience of bringing in coal, iron, lumber, and similar stock, as well as for shipping the product of the shops. This is a matter of all the more importance if heavy machinery is to be built, as the unnecessary handling of such products entails an ever present expense, which, in the case of having the convenience of a branch track to the works is practically met by the first cost of laying the track.

The ground selected should not be in the populous section of a town or city for several reasons, among which are: the high rate of taxation, the continual expense of obtaining a proper water supply, and the largely increased cost of the real estate necessary for the purpose. One manufacturing plant in a city of moderate size is now paying annually the exorbitant sum of forty-five dollars per employee for taxes, and three dollars per employee for a water supply. In the outskirts of a city of the same size and advantages, the rate of taxation would be reduced to less than five dollars, and the water supply, if the plant is near a natural water-way, would be practically nominal. And

if not near a natural supply of water, it may be obtained in abundance by boring, or by driving wells, the first cost of which will practically end the expense.

Obviously, the buildings should not be erected on low ground, where the health of the employees may be endangered by inefficient drainage. Such land is not only unfit for the erection of manufacturing buildings, for the reasons given above, but low ground is liable to be of such a soft and yielding nature as to render foundations expensive and uncertain, particularly if the building is to be a heavy one, or if much heavy machinery requiring masonry foundations is to be used.

Buildings should not be erected on alluvial soil if it is possible to locate on land of a more substantial nature, for the above reason, and in consideration of the health of the employees.

The land should be of hard gravel, as being the best quality for the purpose, as strong foundations may be economically built, and the surface water is readily absorbed in places where it is inexpedient to drain it away. Rocky and clay land will, of course, offer a good bed for foundations, as the solid rocks may be built around and upon and the clay is very apt to be underlaid by a good "hard pan" of compact gravel which is an excellent bed for the same purpose. In building upon rocks, care must be taken to have all resting places for the foundation level, and if the original surface is not so, it must be chipped out, or cut to a level surface, or to several step-like horizontal surfaces, before any stone or brickwork is laid upon it.

As a matter of convenient drainage the ground should be high enough from some proper point where sewerage waste may be discharged to admit of a proper incline to the sewer and its connecting pipes. This is assuming, of course, that the plant is provided with its own sewerage system, as will necessarily be the case if it is outside of city limits, or in a country town where it is not within reach of the public sewers.

In planning a sewerage system the surface water of the yards must be properly taken care of. In grading the yards they should incline slightly toward some convenient point, as much out of the way of the passage of teams as possible, where a catch basin with a water seal trap may receive all of the surface water and still cut off sewer gas, and where convenient connection may be made with the sewer system.

Preferably, such catch basins and the connections from the roof water flow, or a good portion of it, should be furthest from the sewer outlet, and the connections from the wash rooms and water-closets enter the sewer at intermediate points, as this will provide for automatically flushing these connections at every rain storm. Conductor pipes from the roofs should lead directly to the sewers, rather than to pour the water out upon the ground, as

in the latter case the conductor pipes will continually freeze up in winter while in the former case the warm air from the sewer will always keep them clear even in the most inclement weather. A makeshift for keeping ice out of conductor pipes is to run a jet of steam into them near the ground. This does not always keep them clear and the tendency of the steam in cold pipes is to condense and the warm water thus produced soon rusts out the pipes, causing a frequent outlay for repairs, as well as the cost of the steam supply; while connecting them directly with the sewers, the first cost is the only one except the usual and unavoidable wear of the pipes.

Certain areas about the yards will need paving, as, for instance, the driveways, the space around the catch basins, protecting strips around the foundations of the buildings, and in similar places. Very hard tar concrete makes an excellent driveway, unless it be used for very heavy trucking where the horses are liable to slip, particularly in wet weather. To avoid this a brick pavement, constructed with brick set on edge and the courses arranged at right angles to the line of the driveway, will be found an excellent surface. The bricks should be the regular hard paving bricks such as used in street paving, and laid by men who are expert workmen at this class of paving, to insure success.

Cobble stone pavements are more economical and are very durable, but not as neat in appearance or as agreeable when we must walk over them frequently.

The protecting strips around the foundations of the buildings should be of the ordinary tar concrete such as is used for sidewalks, and should be not less than two feet wide and incline away from the building not less than an inch to the foot.

For large areas of yard space the ground should be brought nearly up to the desired grade and then covered with fine gravel, or fine cinders, rolled down hard. It may be rendered more firm by the addition of fine, dry clay, which, when sprinkled lightly with water and then rolled down, will form a "bond" to hold the cinders together. Another method, where cast iron chips from lathes and planers are plenty and cheap, is to sprinkle these evenly over the fine gravel, mix the two together with a hand rake, then roll down hard. Then sprinkle with water, and the rusting of the iron chips will in a little time form, with the gravel, a hard, compact mass. If this has been laid to the depth of even two inches, in a proportion of equal parts of iron chips and fine gravel, and allowed to lie without disturbing for a month or so, subject to rains, or occasional sprinkling, it will make a very satisfactory yard surface for any use except heavy trucking.

Around catch basins, tar concrete should be laid for a distance of five to ten feet in all directions.

Where the grounds are large and the crossing of specially prepared driveways interfere with the grading to induce a flow of surface water to the catch basin, a small water-way should be provided under it at proper intervals. This may be built of bricks, but still better, with a brick floor and an arch composed of an inverted U-shaped section, or sections, of cast iron an inch and a quarter thick. Ordinarily the space need not be over six inches high and eight to twelve inches wide. This form will be less liable to injury by driving over it; it will not be subject to displacement as if built of bricks, and may be more readily cleaned of ice and snow in winter.

Catch basins should be covered with slightly arched cast iron gratings, the purpose of the arching being to prevent it from being easily clogged by bits of rubbish which may be washed to it by a heavy and sudden downpour of rain. Catch basins should be constructed of such dimensions that they need be cleaned out but twice a year, although by building them of double the capacity they may be only cleaned once a year, which had better be done in the summer or early autumn, before cold weather comes on, as a more convenient time than in the spring when snow is melting, the frost coming out of the ground, and the work becoming more disagreeable. As to the capacity of these catch basins, they should contain, up to the top of the bridge-wall, about one cubic foot to every hundred square feet of yard surface to be drained. This will be amply sufficient for annual cleaning.

These observations are intended to be practical. They are the result of experience as well as observation, and the more care and consideration that is given to the few matters to which attention is directed in this chapter, the less we shall be annoyed by the incidental and usually considered accidental expenses that so frequently cause much unexpected trouble and outlay in the regular course of the management of manufacturing plants.

PART SECOND

MACHINE SHOP EQUIPMENT

CHAPTER XVI

MACHINE SHOP EQUIPMENT

General features. The special scope of this portion of the work. The usual errors. A practical view of the subject. General requisites. Proper equipment for a medium class of work. A definite and comprehensive plan for manufacturing operations. The results of a lack of a proper plan. The business that "ought to pay" but does not. Too much conservatism. Seeing the end from the beginning. The only proper plan. Possible enlargements must be provided for. The "piecemeal" plan. Ill-considered and expensive alterations. The last state worse than the first. Better to make new things than patch up old ones. A complete and symmetrical whole.

In the preceding chapters of this work, constituting Part First and under the general heading of Machine Shop Construction, we have carefully followed, step by step, the process of planning and erecting a modern machine shop plant, giving special attention to all its parts, discussing the various plans and methods of construction, and describing the most approved forms of foundations, walls, roofs, floors, etc., and properly providing for the prime necessities of light, heat, ventilation, and power.

We have given special attention to the requirements of manufacturing operations and so planned the entire plant as to bring its component parts into a proper relation to each other, even when confined to a very limited land space upon which to build.

Ample provision has been made for all probable extensions and enlargements in the future that may be due to the possible increase of the business for which the plant is erected.

There has been provided a simple and efficient means for the transportation of stock and material and the convenient handling of the same during the successive processes of manufacture.

Some of the various mistakes and difficulties into which the builder is liable to fall by inconsiderate planning and execution of his work have been pointed out and commented upon.

The endeavor has been made to lay all these matters before the prospective builder and the careful and studious reader as some of the results of years of practical experience, constant and conscientious study, and ample observation of the varied and complex phases of this interesting subject.

Having thus carried forward the construction of the machine shop buildings of the model plant to completion, and having them adequately provided with power, light, heat, and ventilation, and thus ready for the next step in the process of making them ready for active and effective work, we will proceed with the duty of describing and illustrating their equipment with the proper machinery, tools, and appliances for accomplishing the contemplated work to be done. Machines should be so arranged in groups or departments as to best subserve the purpose intended, and to manufacture the product with the least cost for handling the materials in the various stages of their progress toward the completed product, and with the most efficient arrangement for supervising the work, and still to insure the desired standard of accuracy, finish, and thoroughness of the completed output.

In considering the question of the proper equipment of a machine shop a great deal depends upon the character of the product which is to be turned out. It may be that of heavy machinery requiring little or no machining except of surfaces in contact, as is the case with such work as sugar mill machinery, rolling mill work and similar product which will necessitate heavy castings and consequently a large proportion of machines for heavy planing, boring, drilling, tapping, and so on, as well as large erecting space and much use of the traveling crane and other forms of lifting devices.

Again, it may be of a generally lighter kind of work, as for instance, steam engines of various sizes and similar work where much more finish as well as very accurate fitting is required. Or, it may be of machine tools, the larger of which will be similar to the engine work in many respects, while the smaller machines will require a large variety of machines both for general and special work and such as are capable of producing a large quantity of very accurate work even on rather large parts.

The design and aim of this portion of our work is not to arrange and specify such an equipment as may be required for any certain kind or class of manufacture, or for any special line of sizes of machines, for that is manifestly impractical, but rather to suggest the proper selection and arrangement of the machines for a medium kind of work, on a practical plan which may be useful to those having charge of this class of mechanical engineering and be helpful in pointing out such machines as will be most economical in the production of certain classes of work in the more modern and up-to-date methods, and so grouping and arranging them as to make their management easy, practical, and profitable.

In this connection it will not only be proper to offer some suggestions as to the class or type of machines best adapted for certain kinds of work, but also as to the methods of testing such machines to ascertain their fitness for the work to be done on them.

These requirements become all the more imperative since the demand is more and more pronounced for machines of higher speed, greater strength, and consequently capable of a largely increased output, as well as for machines whose parts may be rapidly changed to adapt them to a large variety of work. To this is added the demand for greater accuracy, better fitting, a superior quality of stock in their make-up, a more carefully considered design, and a generally finer finish.

In all the operations of manufacturing, from the very conception of the idea that we *will* manufacture, to the final marketing of the product, if we are to expect success, either in the building, the equipping, or the management of the manufacturing operations of such a varied and complex nature, we must first of all have a well-conceived, well-matured, definite and comprehensive *plan*. If this is not so we shall find the various component parts of our fabric disproportioned to each other. One will be of too great capacity and another of too little; one portion will be an unnecessary expense which will absorb the profits of another; one will be pushed while another is neglected; and so on until the whole establishment is in such a disjointed, disproportioned, and inefficient condition that success either mechanically or financially is impossible.

This is very forcibly shown in cases where a business that "ought to pay" seems to drift along from year to year with scarcely any advance in methods or profits to its owners. Another man takes charge and perhaps astonishes every one by his seeming extravagance, but gradually order comes out of chaos, the expenses which at first staggered the good old conservative directors begins to tell, and in due time everything is in proper condition, every portion of the concern does its allotted part, each in harmony with the others, everybody is cheerful and satisfied, better work is produced, and the stockholders are getting their dividends. Why? Simply that the man is master of the business and works with a well-conceived plan. He knew from the beginning just what would be the result; he was not afraid to make radical changes; there was no patchwork about it. Every portion of his plan was carried out in its entirety. Two different parts do not make a complete whole, and to have several plans in mind and then attempt to carry out a portion of each is but to invite failure. And the invitation is usually accepted.

This is also true even in regard to minor operations in the same line. We must get such a grasp of the complete idea and plan in all its details that "from the beginning we can see the end."

One of our most successful designers of machinery always seemed to be a good deal of a laggard during the first stages of a new design and would draw and sketch and measure in what seemed a very desultory sort of a way. When remonstrated with for what "the boss" thought was wasting time, he

used to say, "I don't want to make my drawing until I can shut my eyes and see the machine working." The complete conception of the design as it gradually forms in the mind is what is needed. And when the man had the ability to thus "see through" the whole design, the "working up" of the various component parts was to a great extent a matter of mechanical detail only.

So it is, or should be, in planning manufacturing operations. We must see the end from the beginning. This applies with peculiar force in the alterations of, or additions to plants already in existence, whether it be the changing on account of a different product to be manufactured, or of enlarging so as to increase the product. The plan should be comprehensive and provide for possible enlargements in the future, so that as each successive change is made we get nearer and nearer to the ideal of a completed structure that will be a credit and not a continual "eye-sore." Not only in appearance is this the proper method, but in the utility of the improvements made, and this again in proportion to the expense incurred.

If any "piecemeal" plan is adopted from time to time the result will be not only a failure to get the greatest accommodation out of the improvement, but to do so at an expense which is frequently lost by subsequent alterations of such a nature as to compel us to tear down a portion of the former work.

And this process is repeated again and again until the expense of successive changes, additions, and alterations will have cost more than to have built the whole structure new. Beside this we have a mongrel structure in which "the last state is worse than the first." It is frequently better to make new things than to patch up old ones; ofttimes it is cheaper also. And this lesson may be followed through all the operations of manufacturing with good results to the reputation of the man who is responsible for the plans as well as the success of the establishment and the dividends to the stockholders.

It was from considerations such as these that in the second chapter, on Construction, it was pointed out how the capacity of our manufacturing plant might be economically increased and at the same time work along the same general lines so that the enlarged structure would be but an extension or expansion of the original plan and the whole structure become as complete and symmetrical in all its proportions as if it were built at one time and from a complete set of plans from one well considered design.

CHAPTER XVII

PLANNING THE DIFFERENT DEPARTMENTS

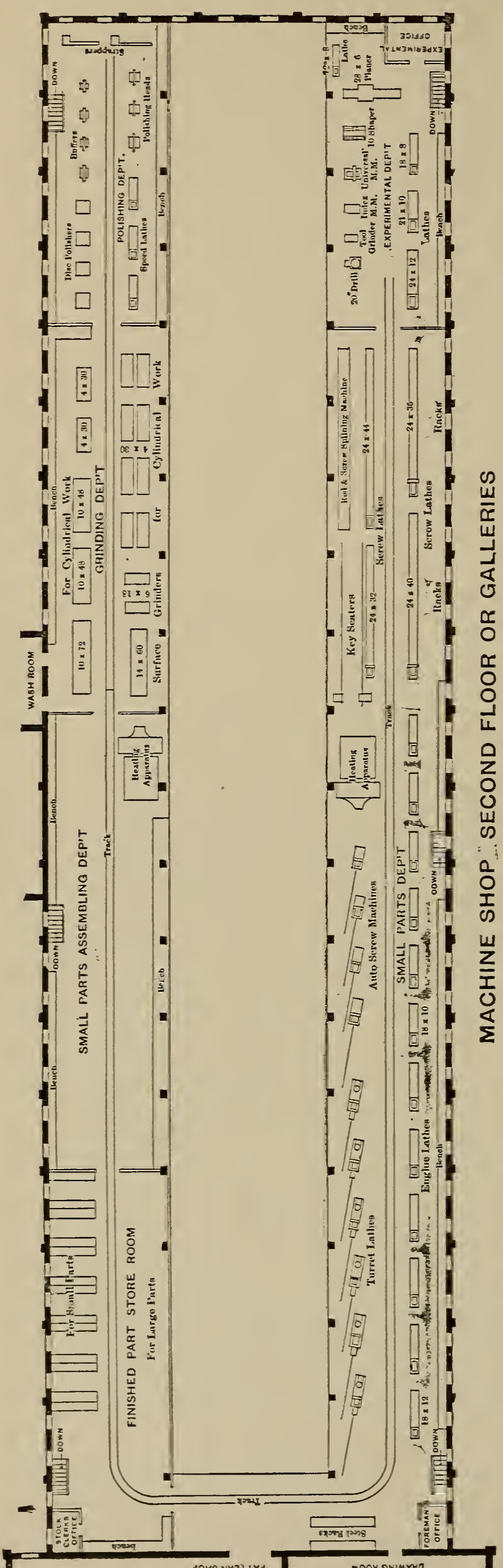
Location and arrangement of the departments. The routine of passing the work through the several departments. The planing department. The drilling and boring department. The heavy turning department. The milling and gear-cutting department. The small parts department. The grinding department. The polishing department. The small parts assembling department. The small parts storeroom. The experimental department. The foremen's offices.

LET us next proceed to lay out and plan for the different departments that may be necessary to carry out our manufacturing work, bearing in mind that much will depend on their proper location with reference to the buildings outside the machine shop proper, particularly the iron foundry, as well as their proper relation to each other.

In planning the relative location of the different departments of our machine shop in which are placed the several classes of machines it is necessary to so arrange them that when once the material, as iron castings or other heavy stock, comes into the shop, it shall pass in as nearly as may be a continuous line through the shop from its rough state to its place in the erection of the machines to be built, with little or no "retrograde movement" or other unnecessary handling or similar expense. Light and easily handled stock is not subject to these conditions to such an extent, and may be handled on the upper floors as its transportation from place to place is easily effected by the tram cars, trucks, etc., on the level, and these run upon elevators, and carried to the various floors where they are needed for the different operations upon them, or to a finished parts storeroom, where they may be kept until they are wanted for the assembling of a complete machine. In our case, however, having but two floors, quantities of small work may be packed in trucks, cars, or boxes and from the front gallery lowered to the ground floor by the traveling crane. In the same way stock or finished parts may be brought up to the gallery floors.

The plans accompanying this article, Fig. 79 show the ground floor and Fig. 80 the gallery floors, with the location of all the machines selected to equip the shop arranged as is thought best for the easy handling of the stock and the

Fig. 80. — Machine Shop Second Floor or Galleries.



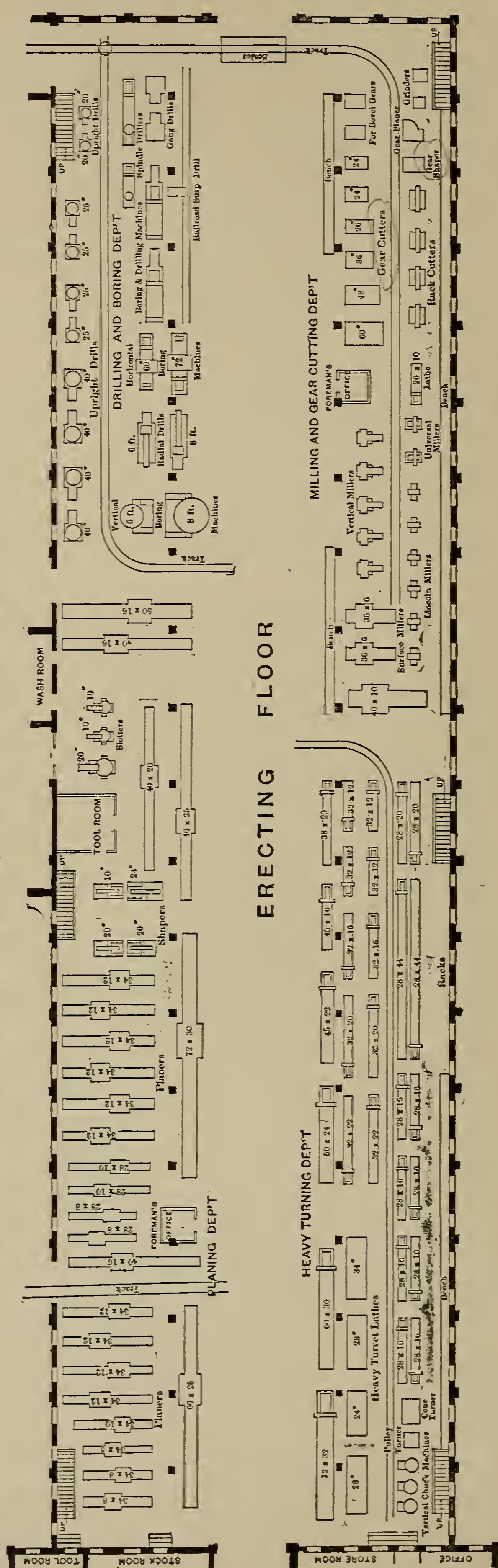


Fig. 79. — Arrangement of Tools and Departments in Model Machine Shop.

convenient performance of all the necessary work of machining, erecting, and shipping. The machines are all shown drawn to scale, and with sufficient space around them for readily handling the stock and the machined parts.

The main floor is divided into five departments, namely, the Planing, Drilling and Boring, Heavy Turning, Milling and Gear Cutting, and the Erecting Departments, all located as shown on the plan.

Usually the first operation on nearly all castings and on many forgings is that of planing, this being particularly so with the heavier stock. Consequently it is advisable to locate the planing department near where this class of stock can be the most readily received into the shop from the foundry or from the forge shop. As by far the larger amount comes from the foundry the point nearest that department is where the planers should be located, so as to save distance in conveying material, and consequent expense. Our tram track leading from the foundry to the machine shop brings castings to a point nearly under the traveling crane (by which they are readily placed upon the planers on each side of it), or directly under it, by which it conveniently serves the large planers located in the erecting space just inside the row of columns.

An overhead trolley delivers castings to the other planers in the row arranged at right angles to the shop as they are taken from the foundry cars, or carries them, when planed, to the tram track and thence by the traveling crane to any part of the shop where they may be needed, generally to the tram track laid through the drilling and boring department, or to the large machines of this class located within the reach of the traveling crane inside of the columns. This overhead trolley may be operated by hand hoists, or by compressed air, but preferably it should be of the type carrying a small electric motor by which it is very quickly, efficiently, and conveniently operated. There should be at least two of these hoists on the trolley track, which should extend from the front end of the shop down to and over the tram track in the drilling and boring department.

It should be explained that in laying out the positions of the planers the outline shown includes the extreme run of the planer table, hence there is more space at the ends than would appear at first glance. In locating the planers with reference to each other they are placed at equal distances of five feet between tables without regard to the front or back, so as to give free access to both sides when the operator is putting on, setting, or removing work. Those of the larger planers are located parallel with the length of the shop. It will be best to drive these with electric motors. The other planers, of such sizes as will accommodate the usual variety of work, are located according to the space available.

Much of the medium sized work may be done on long planers very

economically by filling the table with as many parts as it will hold, and running through the lot with a long cut, as for instance, with lathe heads or carriages, which may be planed in lots of ten to fifteen much cheaper than a less number on a short planer. The two planers near the wash room are convenient for comparatively large work where a short table is required. The other planers are arranged in pairs facing each other so as to be convenient for one man to run two planers. One man can easily run the 60-inch and the 72-inch planers.

In connection with the planers are located the shapers and the slotters, as shown in the plan. These are also served by the overhead trolley as noted above, and work from them or from the planers may be thus conveniently moved to the drilling and boring department unless the parts are so large as to make the traveling crane necessary.

Next in the order of work is usually that of boring, either in vertical boring mills, horizontal boring machines, radial drills, etc. Therefore this class of machines will naturally come next to the planers, and on the same side of the shop, in the drilling and boring department. The vertical boring machines are of the usual type in which much of the large work, such as pulleys, balance wheels, and many other heavy parts, are much more readily handled than upon a lathe. The horizontal boring machines are those with the low, traversing table, and elevating head and tail stocks, while the horizontal boring and drilling machines are those with a stationary head and an outer support for the boring bar, and a vertically adjustable table supported by two vertical screws. The first is adapted to heavy work, while the latter handles that of medium weight.

The so-called railroad suspension drill is one provided with a perfectly level track upon which long beds, as lathe beds, may be supported on rollers and run to any desired point in their length for drilling and tapping. Assuming that there will be hollow spindles required, two spindle boring machines are provided. These may be of the horizontal cylinder type for the purpose of feeding, where only one tool is used, or with a heavy turret and slide when more than one tool is required. Two gang drills are provided for jig work where medium or small sized holes are needed. Next to the wall is a row of ordinary upright drills of the capacity indicated. Where necessary, small jib cranes should be attached to the columns for use at individual machines, or for a pair of machines.

The Heavy Turning Department, on the opposite side of the shop and at the front end, contains all lathes of 28-inch swing and upwards. Also the heavy turret lathes for cast iron work and the larger parts of steel or other material. Here are also the vertical chucking machines, which are in many cases to be preferred to those of horizontal type. The lathes of 38-inch swing and upwards are placed inside of the row of columns so as to be served

by the traveling crane. Nevertheless, small jib cranes attached to the columns and operated by hand will be found very useful for a number of the other machines.

The cone-turning machine should be arranged to turn and crown all the steps of a cone at once. This and the pulley-turning machine are located convenient to the vertical chucking machines. Two shafting lathes of 28-inch swing and 44-feet beds are provided. In locating the lathes a space of four feet is left between the ends so as to give free access to any part of the room. Material is brought in on the tram track, one end of which extends out under the traveling crane. The heavy turret lathes and the vertical chucking machines will handle much of the work frequently done in the engine lathes and do it much quicker, thereby saving the number of the latter to be set up.

Next in order is the Milling and Gear-Cutting Department. Here surface milling machines are provided for large surfaces, while smaller surfaces are taken care of by the six plain, or Lincoln millers. Two universal millers do the more complicated work and a small lathe is put in as a convenient machine to save going to another department for small and simple jobs of turning. The five vertical millers will do a large quantity of work very accurately and at better advantage than planers could do it, and at the same time at a much less cost for labor, as is the usual result with milling machine work.

Six gear cutters are provided for spur gears, and two for bevel gears, while a special gear shaper and a gear planer will do the work required to be particularly accurate. Four rack cutters will usually be a proper proportion to the above. While the cutters for these machines are made in the general tool room, two grinders are provided so as to keep them in order in the department where they are used. A convenient extension of the rear tram track furnishes means to bring in and take out work.

The gallery floors are divided into six departments, namely, Small Parts, Grinding, Polishing, Small Parts Assembling, Small Parts Store, and Experimental Departments. A tram track connects them all, passing through the cross gallery at the front end, under a traveling crane, by which any machine, car, truck, or lot of stock may be quickly transferred to or from the main or ground floor.

The Small Parts Department is the largest of the six and contains six turret lathes for making steel work from the bar, and four automatic screw machines for smaller work and for such special screws as may be made in the shop more economically than they can be purchased. A line of engine lathes of the sizes given on the plan handle such small work as requires to be turned on centers. Long lathes for turning and threading leadscrews and similar work are provided, as is also a machine with a traveling head for milling the

splines in long rods or screws, and two small key-seating machines for milling semicircular key seats. Racks for bar stock are provided in the front gallery and near the screw lathes for stock and for finished work.

The Grinding Department and the Polishing Department are for obvious reasons placed as far from the other work as possible. Much of the cylindrical work is sent to the grinding room to be reduced to perfectly cylindrical form on wet grinders and does not require any polishing finish. For this work three large, two medium, and eight small grinders are provided. One large and two small dry surface grinders are arranged to take such small parts as require this treatment.

The Polishing Department as now known in connection with a machine shop is somewhat new in this class of machine work, but its importance and efficiency is becoming more recognized as its usefulness is being demonstrated. Four disk grinders or polishers are provided for small or medium sized flat surfaces, and work direct from the planers is quickly polished to a fine finish and quite true. Three speed lathes are expected to do all the small cylindrical work that has not been ground.

Work requiring a bright buffed finish is taken to the four buffers, while irregularly shaped parts are polished on the three polishing heads or on the two belt or strapping machines. This room, of course, enclosed as tightly as possible to avoid the difficulty of floating particles, or grinder's dust passing to the other departments. Nearly all of this trouble may be prevented by a small exhaust fan connected with hoods at each of the machines by a suitable main pipe and branches, by which the dust is discharged in the open air, or a proper receptacle. This has the additional advantage of saving the eyes of the workmen from much annoyance and discomfort.

Small parts when completed are taken to the Finished Parts Storeroom, which is located in the front end of the shop and furnished with shelves arranged in alcoves on one side of the room, while the opposite side is reserved for somewhat larger parts, or collections of parts, as may be necessary. This space should be fitted up to suit the particular kind of work, and may be in broad shelves running lengthwise of the room, or in alcoves as on the opposite side.

Between this room and the grinding department is the Small Parts Assembling Department, in which it is intended to assemble groups of small parts, as for instance, the parts comprising the apron of a lathe, or similar work. If the parts are accurately made no machine work will be here needed, although a small engine lathe might be a convenience at times. Bench vises and the usual assembling "jacks" comprise most of the necessary fittings.

In the back end of the opposite gallery is located the Experimental Department, where small and medium sized experimental work is to be done.

It contains, as will be seen in the plans, a variety of machines suitable for experimental work, so as to render it unnecessary to go to any of the other departments for anything except large turning, planing, and gear cutting. Such a department is a necessity to a shop aiming at making progress and keeping up with the times, as work of this character costs too much if done in the regular tool room, and it is not only an awkward but expensive matter to place it in any other department.

Along the front of each gallery is an iron railing 32 inches high, that on the front end gallery having an easily removable section 12 feet in length, for convenience in passing work to and from the gallery by the traveling crane.

The Foremen's Offices, the Tool-Distributing and the Finished Parts Storeroom are sheathed up with $\frac{7}{8}$-inch pine to the height of 44 inches, above which it is enclosed with wire netting of 1-inch mesh and 4 feet in width. This form of construction affords an ample enclosure and does not materially impede the light. The doors should be provided with spring locks, and workmen generally not allowed in these enclosures except by permission. This is one of the necessary measures of good discipline, and one that foremen should always insist upon, without favoritism.

CHAPTER XVIII

EQUIPMENT OF THE TOOL ROOM AND THE TOOL STOREROOM

First the machine, then the tools for use in the machine. Proper arrangements for keeping tools. The office building. The offices described. The tool-making department. Its location. Its equipment. The foreman's office. The tool storeroom. Its arrangement. Arbor rack. Double rack for drills, reamers, etc. Wide tool shelves. The care of files and the proper arrangement of such stock. Pigeon hole arrangement for drill rods, short bar stock, brass tubing, etc. Tool carriers. Their use and necessity. Horizontal system. Vertical system. The overhead system. The mechanism. The carriers. The operation. The mechanism of the vertical system. Simplicity of the system. The use of distinctive colors. Automatic dumping carriers. Speed of this system. Bins for rough stock, or small castings. Keeping various kinds of stock. Purchased parts storeroom. Its purpose and use. Articles kept in it. Arrangement of articles. Desks. Building stock bins. Painting storerooms.

In the previous chapter we considered in detail the machine tool equipment necessary in the various departments of the machine shop, and the location of the machines in each group or department, all arranged for convenient supervision and for the ready handling of the stock and the finished parts.

In that article the *machines* in which the work was to be done were considered. In this article it is proposed to consider the *tools* for use in these machines, including a department for making them and proper arrangements for their care, such as providing a place for their safe keeping and regular issue to the shop. It is also proposed to consider, in connection with the storeroom for tools, the arrangement of the storerooms for the smaller kinds of rough stock, and such purchased parts as are received complete from outside dealers or manufacturers. This plan leads us into the office portion of the building, and consequently a brief explanation of this part of the establishment does not seem out of place, inasmuch as it is, in a purely manufacturing plant, so intimately connected with all the machine shop operations, rather than partaking of the commercial side of the marketing of the product.

The large engraving cut, Fig. 81, accompanying this chapter, is a plan of the front portion of the machine shop building, showing the relative location of the offices, tool-making department, storerooms, etc., and the essential parts of their internal arrangements.

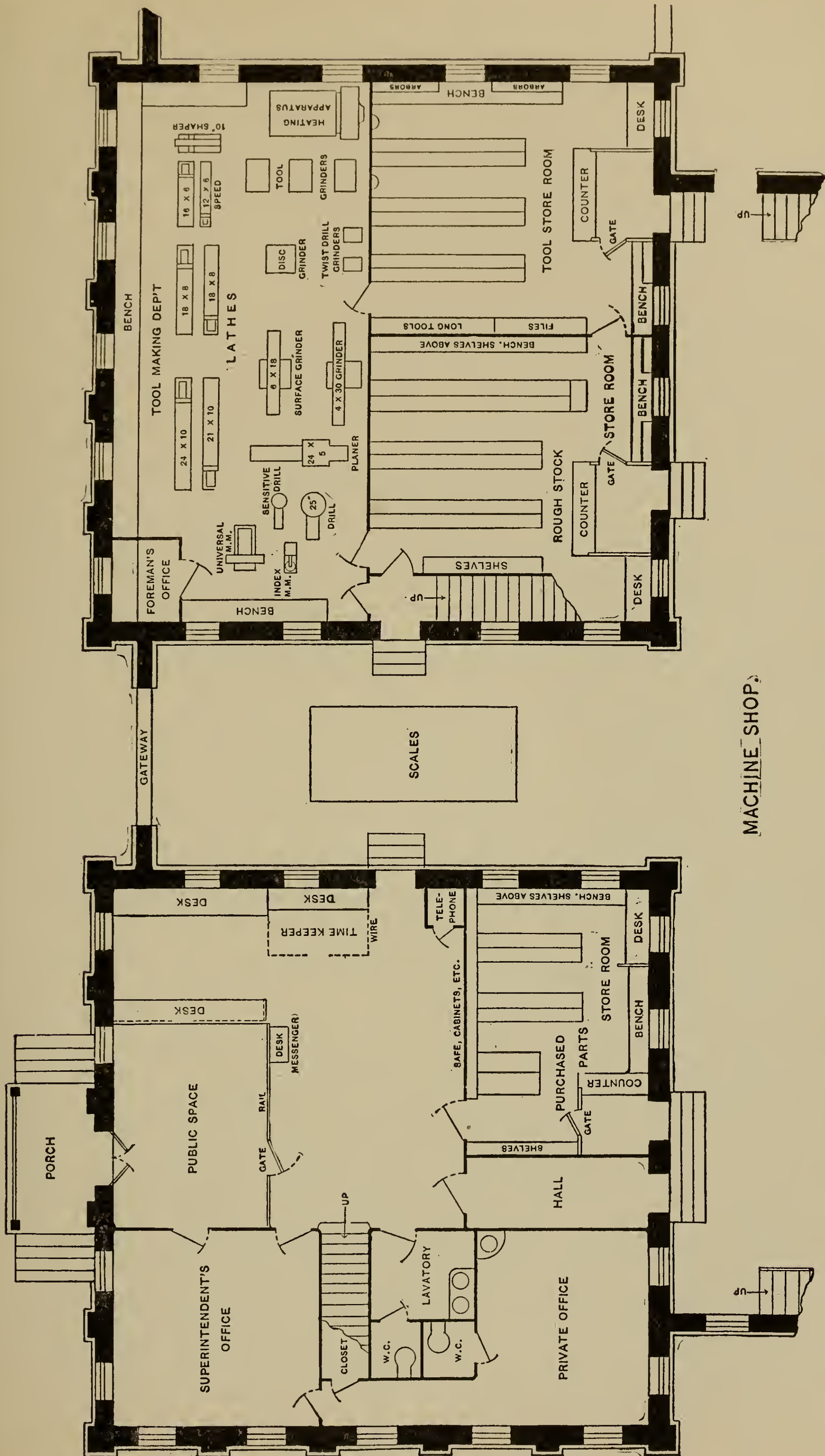


FIG. 81. — Plan of Shop Offices, Tool Room, Tool Storeroom, Rough Stock Storeroom and Purchased Parts Storeroom, all of which adjoin the Machine Shop.

The main entrance to the office part of the buildings is through wide double doors from a large porch and opening into a public space in the portion devoted to office arrangements. The divisions of this portion of the building are clearly shown in the drawings. Upon the outer side are located the superintendent's public and private offices, between which is the stairway leading to the drawing room above, and the necessary toilet conveniences. The public space is separated from the large central space of the general office by a railing, doors opening from both these into the superintendent's public office.

The bookkeepers' desks are so arranged that a cashier's window opens into the public space. The timekeeper's desk is surrounded by wire netting, secluding his work from the general work of the office. A door leads into the gateway space, across the large platform scales and into the tool room portion of the building opposite. At one side of this door and as far away from the general work as may be is the telephone booth. A wide hall leads from the central space to the machine shop proper, and divides the private office from the purchased parts storeroom. This latter is so placed because the purchase, receipt, and issue of such stock is more intimately connected with the office work than that of the rooms in the opposite side of the building.

The tool-making department is purposely placed away from the general machine shop, as a too intimate connection with it does not seem desirable in practice, while it should be convenient to the drawing room and the pattern shop, which may be reached by the stairs next to the rough stock room, as shown. It occupies the entire front of this square, front structure and is provided with a variety of machines rendered necessary for the making of modern tools and fixtures for properly machining small or medium sized parts. The character of each of these machines is indicated on the drawing. It is also provided with the grinding machines for grinding such tools as lathe tools, planer tools, twist drills, etc.

It will be noticed that in providing the machine tools for making jigs and fixtures particular attention is paid to grinding facilities, since these are in many cases the best adapted to such accurate work, both as to producing good work and to doing it economically. Large pieces of heavy fixtures may, of course, have to be planed in the planing department, but these cases will seldom occur. The tempering of tools will best be done in the forge shop, the tools being sent there in quantities when possible, rather than to attempt such work in the tool-making room with hand forges.

A foreman's office is provided so that he may have a proper place for keeping the records of the work of the department as well as a private room for convenience in making such sketches, plain drawings, or details as he may find necessary in carrying out the plans for tool making (these are not always

worked out in sufficient detail by the drawing room force), or such as he may wish to devise himself for special work and develop as the necessities for them may arise.

To avoid confusion in the tool-making department, a tool storeroom is provided, where the usual supply of lathe and planer tools, twist drills, taps, reamers, arbors, etc., is kept and issued to the tool-distributing points such as the general room near the engine room and the foremen's offices. In this room are also kept, when they are not in use, the jigs and fixtures necessary for machining small parts, as they can be better cared for here than in the machine shop. The entrance to this room for the workmen is so arranged that he enters a space in front of a counter and has no access to the main space of the room. This will prevent confusion and enable the tool keeper to do his work quickly and properly.

To save unnecessary distance in reaching all tools and fixtures the alcoves of shelves are so placed that the alleys all terminate near the issuing counter. At the right is a convenient bench arranged with arbor racks as shown in Fig. 82. These racks will accommodate arbors from 4 to 7 feet in length. The same form of racks may be arranged for any length too long for conveniently placing on the shelves. Beneath this bench are strong shelves upon which may be placed heavy jigs and fixtures.

Fig. 82. — Bench, with Rack for Long Arbors, Boring Bars, etc.

Fig. 83 shows cases of inclined shelves arranged with strips for holding such tools as drills, reamers, short arbors, and similar tools, and at the far end another form of arbor rack. This may, if preferred, be arranged similar to the arbor rack shown in Fig. 82. The series of inclined shelves is continued as high as is within convenient reach, and above this point horizontal shelves are provided which will be found convenient for holding jigs, fixtures, and similar articles that are seldom used, and not too heavy to be stored at that height. At the base of these cases a series of large drawers is located. They will be found very useful in storing small tools not needed on the shelves, and a variety of such

articles as are best kept in such a receptacle until wanted for adding to the regular issuing assortment on the inclined shelves.

In Fig. 84 is shown a form of case of inclined shelves for longer tools than can be accommodated in the cases shown in Fig. 83. Otherwise the arrangement is the same. The ends of these cases may be conveniently used for the posting of blueprint lists of regular or standard sizes of tools in stock, from which it will be easy to ascertain if a certain tool wanted is kept on the shelves. They may be used as tool check boards, being convenient to the desk and counter.

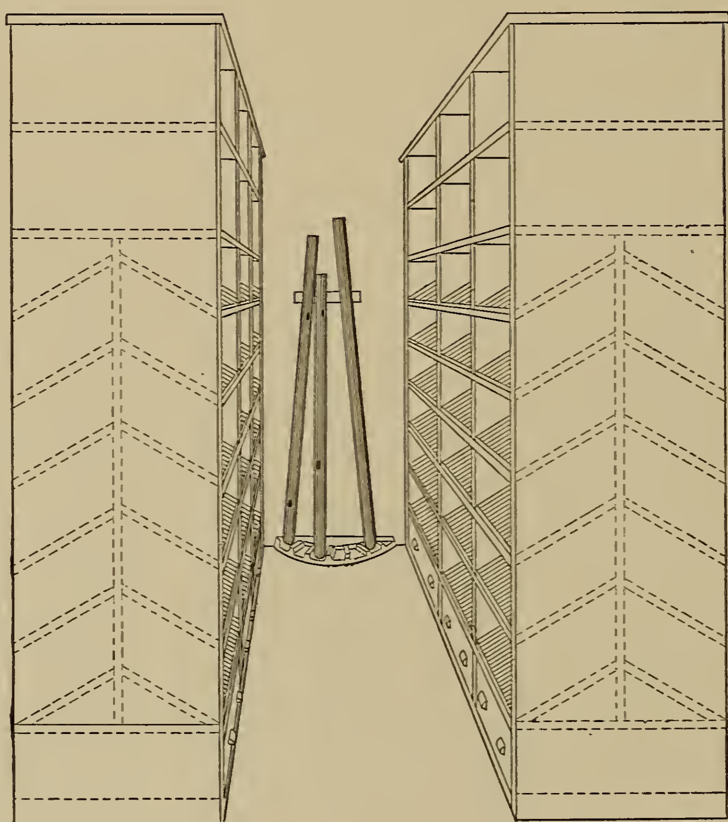


FIG. 83. — Cases with Inclined Shelves, on each side of Alcove.

Fig. 85 shows a file case in which a regular system of arrangement of the files of different lengths, cuts, and shapes are provided for, so as to make the memorizing of their location easy and convenient. It will be noticed that the smaller files, as the 3-inch, 4-inch and 5-inch files, have each one shelf provided for them, while all of the larger sizes have two shelves to each length, as more different shapes and cuts of these are required. Also, that the coarsest cut is placed at the left and the triangular, square, and round shapes follow them toward the right, and that the files of each length are arranged in the same regular order. This arrangement will save much time in issuing files, as well as in distributing stock when it is received. The labels showing the shape, cut, and length are placed on the edge of the horizontal dividing shelves, the *shape* being shown as in the drawing. At the base, and below convenient

reach in issuing, are compartments for stock. The sizes and shapes of files shown are such as are usually needed in ordinary machine shop work.

If a special class of work is done these sizes and shapes would, of course, have to be modified or added to, but the same general plan might be adhered to. As the files at the top of the case are much shorter than those lower down, a waste space will be left in the rear of them. This may be utilized by forming compartments as shown at *aa*, in which drill rods or other similar articles may be placed if such are kept in this room.

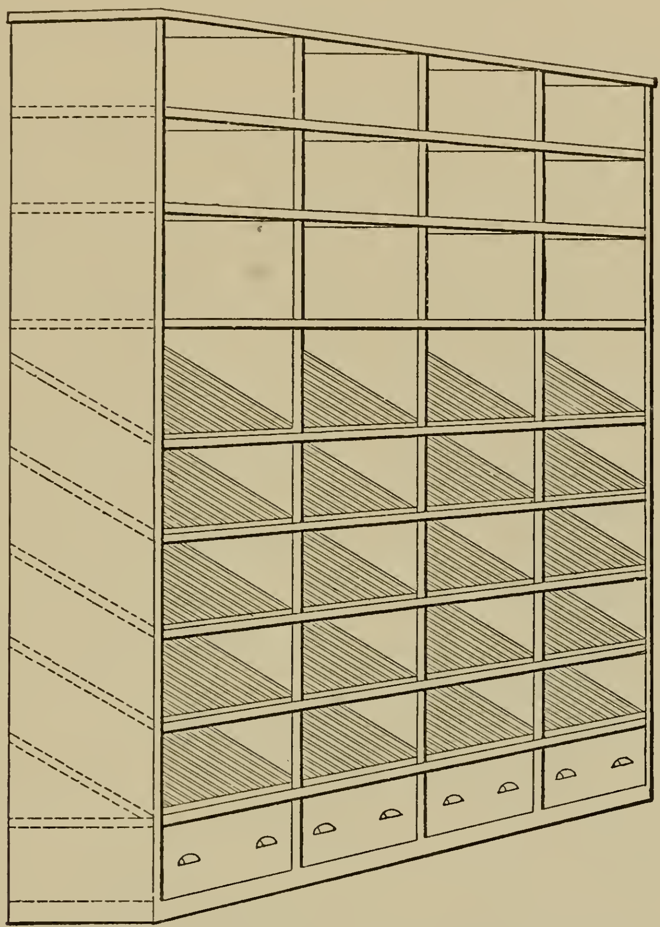


FIG. 84.— Case with Inclined Shelves suitable for Long Tools.

From the window opening into the machine shop a system of tool carriers, similar to the cash carriers or the package carriers of a department store, may be run to the tool-distributing room near the engine room, to each of the foremen's offices, keeping out of the way of the traveling crane, and to the galleries. These will be very useful in sending in dull tools to the tool department to be ground and in quickly returning the same. Also, in keeping these distributing points supplied with standard tools in proper condition for use. Such a system will soon save its initial cost in the time that would otherwise be spent in carrying these tools, not to consider the many delays in the work, which is usually far more important. Several matters more or less closely

related to this subject will be discussed in detail in articles on the management of the work of the establishment.

The speedy and economical transportation of small tools to and from the general tool room is a problem that, while of acknowledged importance in any large establishment, is of sufficient moment in many shops of more moderate dimensions, and should receive a larger share of consideration than is generally given to it. The requirements of modern shop practice that the employees should not leave their machines to grind tools, or to go to the tool room to procure or to return them, becomes a large factor in the problem of their quick transportation, and even with the system of errand boys to do

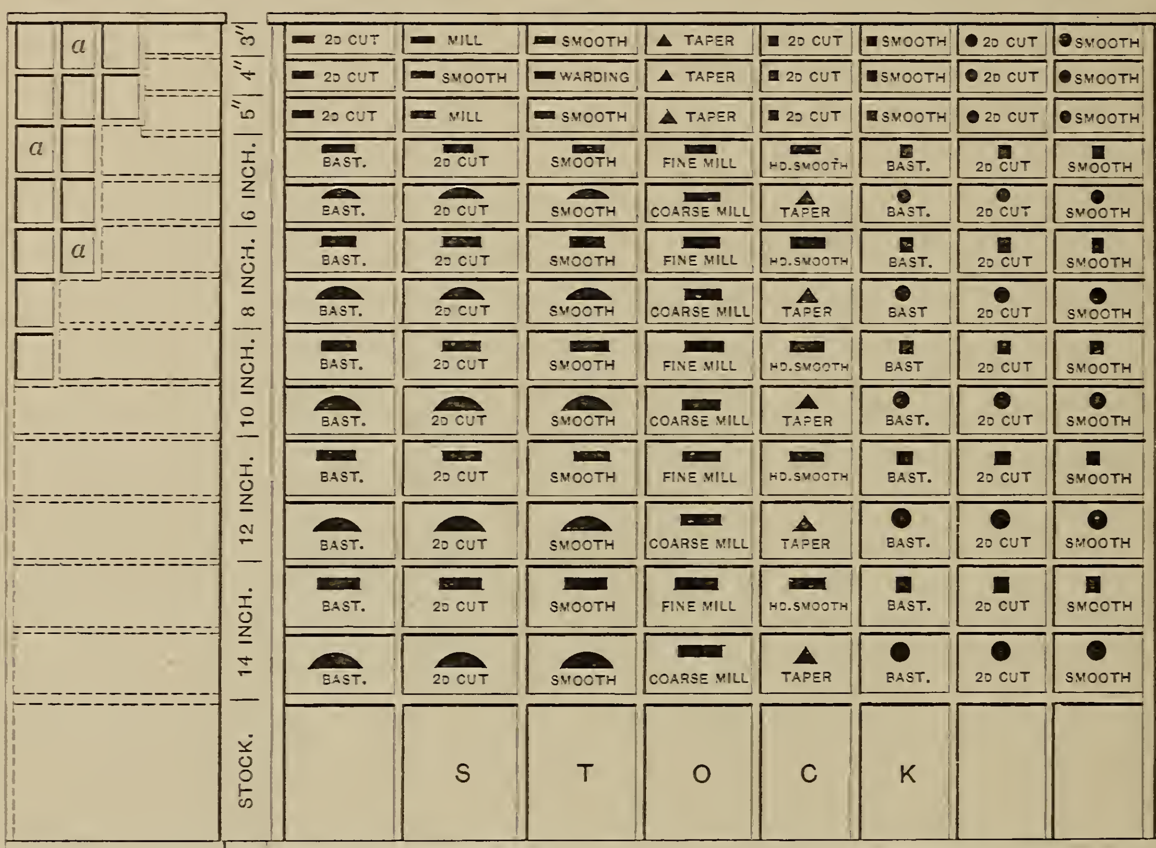


FIG. 85. — Front and End Elevation of File Case.

this work there are many conditions of the modern shop where a good and efficient system of transportation in both vertical and horizontal directions becomes a necessity, if we consider economy along with efficiency.

For instance: In a large plant of one floor, it may not be convenient to locate the tool room near the center of the machine shop for the purpose of shortening the lines of travel of the errand boys. Or, if so located, these lines may still be so long as to cause a considerable loss of time. In this case the establishing of auxiliary tool rooms, while of considerable advantage in the distribution of tools, still leaves the transportation problem untouched and out of the question.

Again, in shops consisting of several floors, as many in the crowded cities must necessarily be, the vertical transportation of tools from a general tool room to and from the several floors should be accomplished as quickly and with as little manual labor as may be.

These being the conditions, it becomes necessary to devise a system of transportation that will accomplish the required results in as economical and efficient a manner as possible, and at the same time occupy as little space in the shop as may be, and that shall not be liable to frequent interruptions from getting out of order. It must, therefore, be some overhead system, when used for horizontal transportation; it must be simple and of as few parts as possible so as to be inexpensive, and to be less liable to disarrangement; and it must practically take care of itself under all ordinary circumstances.

It is believed that the system herein shown and described, if properly constructed and installed, will fulfil all these conditions satisfactorily. In the engravings accompanying this description, Figs. 86, 87 and 88 represent the system of horizontal transportation, and Figs. 89 and 90 that for vertical service. The horizontal system consists of a half-inch braided cotton sash cord, fitted with metal couplings and passing over comparatively large sheaves at each terminal. Upon this carrying cord are suspended hanging receptacles of suitable

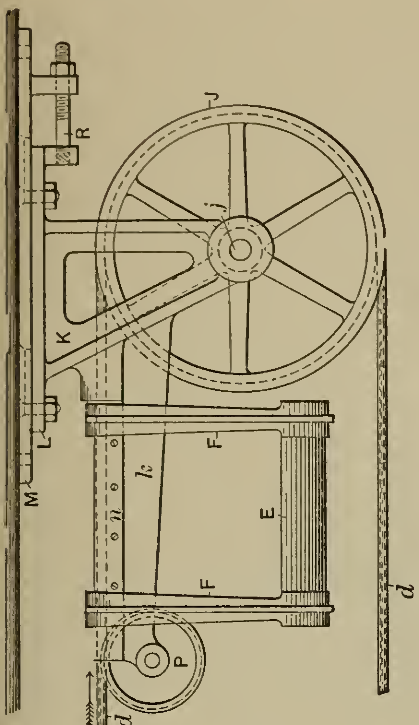


Fig. 88.

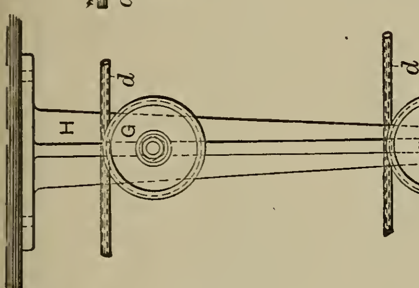


Fig. 87.

Intermediate Support and Adjustable Terminal Hanger of Horizontal System.

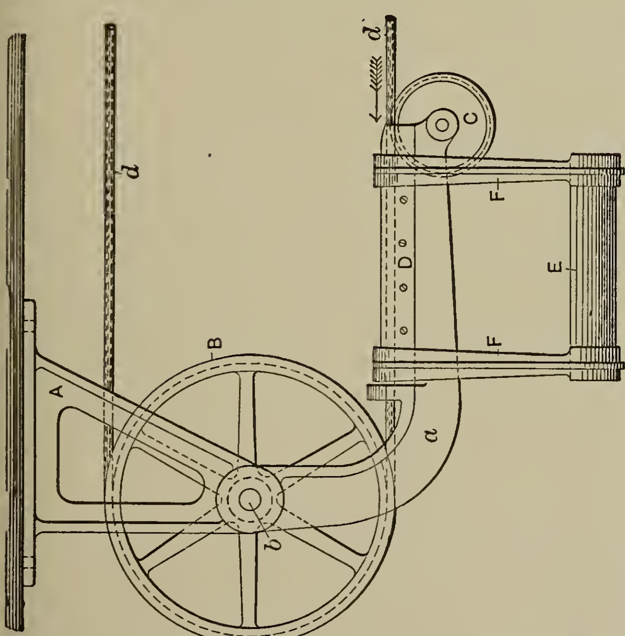
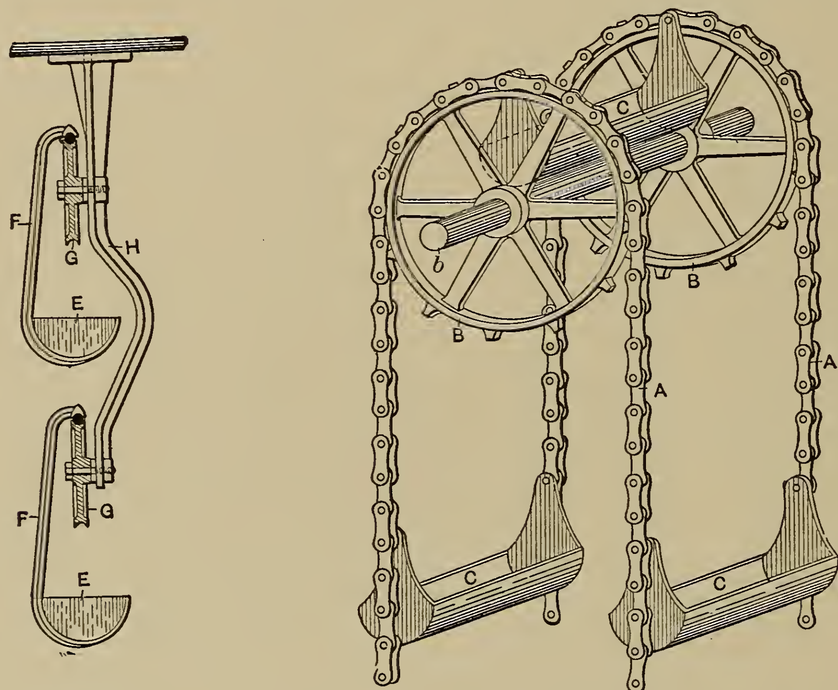


Fig. 86. — Fixed Terminal Hanger of Horizontal Tool Carrying System.

form and dimensions for holding the tools to be transported. Fig. 86 is a side elevation of the fixed terminal, the shaft *b*, upon which is fixed the main sheave *B*, being journaled in the hangers *A*, one of which is of sufficient length to furnish a bearing for the shaft, while the other has formed upon it a curved arm *a*, in the outer end of which is journaled the sheave *C*, for the purpose of supporting the carrying cord *d*, at the point where the carrier leaves the cord in coming to rest. Fixed to the extending arm *a* is an inverted U-shaped piece of sheet metal *D*, covering the carrying cord *d*, and furnishing a resting place for the carrier. This carrier is composed of a box *E*, of sheet or cast metal, with a curved bottom as shown, and suspended by the malleable iron supports *F F*. These are shown in end elevation, the supporting sheaves



FIGS. 89 and 90. — End View of Intermediate Support for Horizontal Transportation, and Carriers, Vertical System.

in section, in Fig. 89, which shows the supporting sheaves *G G* and the bracket *H*, on which they are journaled. This device is also shown in front elevation in Fig. 87. This supporting device should be located at suitable distances along the line according to the loads to be carried, but always near enough to each other to prevent undue shocks as the carriers pass over the supporting sheaves.

The carriers shown are of simple form and will be most useful for carrying the usual variety of small tools. Any convenient form may be used, however, the center of gravity being always kept directly under the carrying cord *d*. They may be made with considerably less drop from the carrying cord, for most kinds of tools, this distance being reduced nearly one half, which will cause them to move with less shock and less of the swinging motion as they

pass along. They should never be relatively lower from the carrying cord than is here shown.

Fig. 88 shows the adjustable terminal hanger *K*, and its connections. In this case two hangers are cast on a plate *L*, or permanently fixed to it, one of them having a projecting arm *k*, carrying the supporting sheave *P*, and being provided with the U-shaped cord shield *n*, similar to that shown at *D*, Fig. 86. The plate *L* is arranged to slide upon the plate *M*, and is secured to it by two bolts as shown. The adjusting screw *R* is provided for taking up any slack that may be in the carrying cord *d*. The main sheave, *J*, is fixed upon the shaft *j*, which is journaled in the hangers *K*.

In operation, the device is driven from a pulley of suitable size on the shaft *b*, and at such a speed as will give sufficient momentum to the carrier *E*, to cause the carrier arms *F F* to ride up on the whole length of the cord shields *D* and *n*, and stop there with very little shock, the carrying cord running in the direction of the arrows. In use the carriers have only to be taken off and hung upon the returning portion of the carrying cord to return the empty or loaded carrier. Upon the arrival of a carrier it glides up on the cord shield *D* or *n*, and remains there until removed. Should a second carrier arrive before this one is removed no harm is done, although it is expected that they will be removed as soon as they arrive. The cord shields *D n* may be made long enough to accommodate two carriers, but this will seldom be found necessary.

The vertical system is shown in Figs. 89 and 90 and consists of two parallel chains *A A*, passing over the sprocket wheels *B B* at the top and under similar ones at the bottom. These chains may be driven from either the upper or lower shaft as may be most convenient. Pivoted to these chains are the carriers *C C C*, which may be made of cast or sheet metal, and so formed, with the center of gravity considerably below the pivots, that they may always remain right side up, even when passing over the shaft *b*. These carriers should be about eight feet apart on the chains, and they should be painted a different color for each floor to which they are consigned, so that their contents may be readily removed at the proper destination without stopping the movement of the device for that purpose, it being understood that all descending carriers are consigned to the tool room on the first floor, or toward it, provided it is located on any other floor.

These carriers may be so constructed as to automatically dump their contents at the proper floor without the attention of an attendant for that purpose. This system may be used in situations where continued vertical and horizontal transportation is wanted, by running the chains over guiding sprocket wheels at the proper turning points, as the carriers will always maintain their proper positions no matter what may be the direction of movement

of the chains. However, for long horizontal distances this system will not be found as economical or as efficient as the first method described.

The chain system should be run at a much slower speed than the cord system, as the carriers should be unloaded while in motion, while those on the cord system come to full stop until they are again wanted. Each will be found to be best adapted to its own particular sphere of usefulness as herein described.

In the rough stock room the cases are also arranged in alcoves, and are of the form shown in Fig. 91. These are made wider at the base to accom-

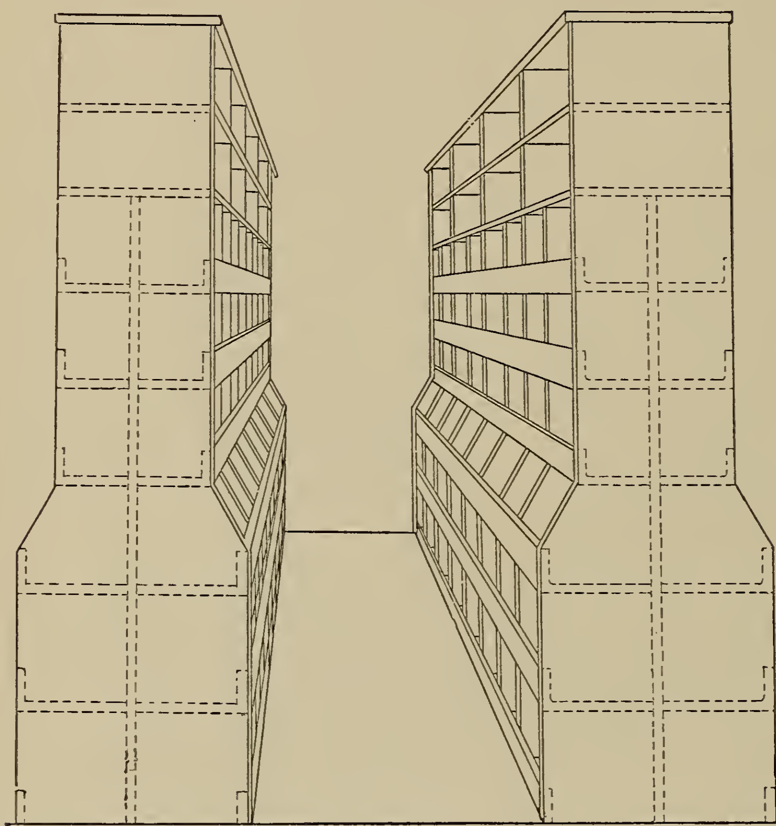


FIG. 91.— Modified Form of Stock Cases with Lower Bins Enlarged.

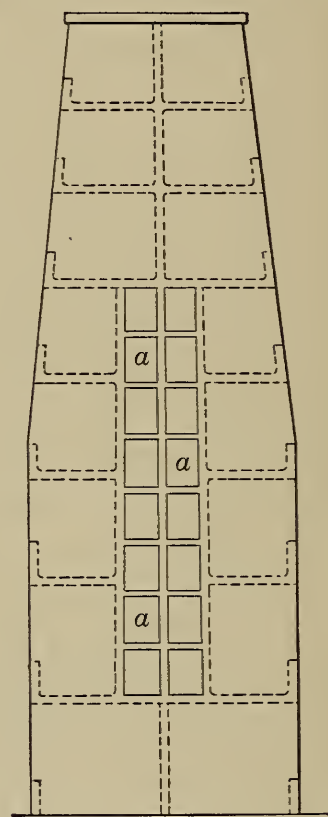


FIG. 92. — Modified Form of Stock Cases with Pigeon Holes for Rods, Tubing, etc.

modate larger articles which are more conveniently handled at this height than higher. The construction is plainly shown in the drawing. At the upper portion plain shelves are provided to hold articles seldom used or of such irregular form as are not convenient to store in bins as arranged below. These may be constructed with a retaining strip at each side, thus forming bins all the way across the case, if the form of the articles stored renders it necessary. In Fig. 92 is shown a modified form of these cases, in which the center portion has formed in it compartments *aa*, in which may be stored round and square cold drawn steel, brass tubing, and similar articles, in a safe and convenient manner and without occupying any additional floor space. Fig. 93 shows a

case, the front end of which is arranged to hold such articles as sheet brass, copper, or vulcanized fiber, in a similar manner to that provided for storing large window glass. This form of construction will be found better than to lay sheets in a horizontal position, as they can be more conveniently reached, and by providing entirely separate compartments for each thickness, small pieces can be more easily cared for and readily found when wanted.

Wire in coils may be hung upon the walls. It should be so assorted and arranged that all of one material shall be together and that the smallest size is at the top, or at the left of the group.

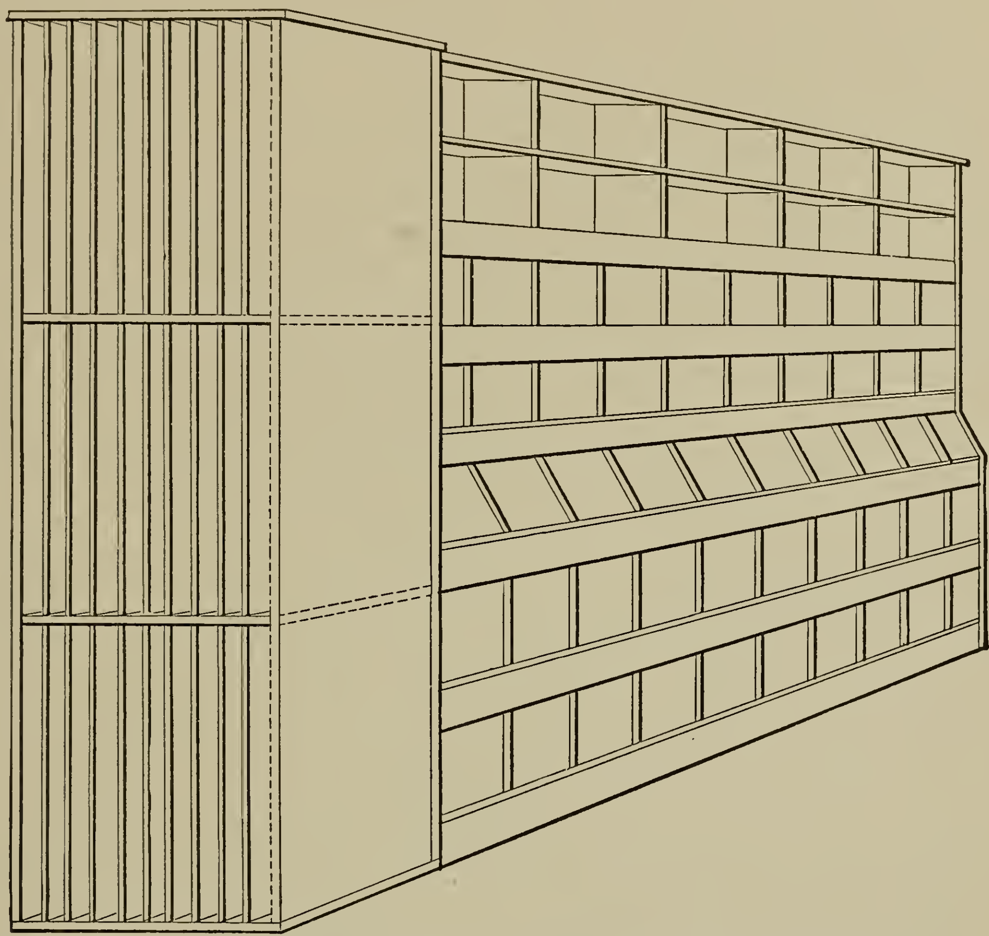


Fig. 93.— Combination Stock Case with Compartments for Sheet Metal, etc.

Various modifications of these plans may be necessary in adapting the arrangements to different conditions and classes of materials to be handled, but in a general way the construction shown will be the most useful, both as to the proper storing and care of the stock, materials, and tools, and as to their convenient and consequently speedy delivery when called for.

Cotton waste, or whatever equivalent is used, may be kept in a bin built under the bench, or in a similar one built under the stairs.

A small counter scale weighing up to 80 pounds and provided with a pan for weighing small articles should be provided for the counter.

The Purchased Parts Storeroom is located in the office portion of the

building and is arranged in a similar manner to those just described. All articles purchased outside of the shops and in a complete form to enter into the work, are here received, stored, and issued. This will include all kinds of screws, bolts, hardware, belting, belt fastenings, etc. It might include files, but they are here classed as tools and put in the tool storeroom. Oil cans, hand lamps, file cards, emery cloth, grain emery, etc., may also be kept in the tool storeroom, as being more nearly allied to tools than to either rough stock or purchased parts. For the same reason it might be well to place belting and belt fastenings in this room.

Returning to what may strictly be considered purchased parts, the following arrangement of them will be found to be convenient and practical, both for proper storing and for issue. Machine screws should be kept in the original gross packages, on shelves not necessarily over 6 inches in width, and for the smaller sizes 5 inches apart; for the larger sizes about 9 inches apart. For eighty sorts, say from $\frac{1}{4}$ inch 6-32 to 2 inch 24-16, and in both round and flat heads, there will be about twenty linear feet of shelving required, exclusive of vertical supports. Set screws are also kept in the original packages on similar shelves. Thirty-four sorts, from $\frac{1}{4}$ inch x $\frac{3}{8}$ inch to $\frac{3}{4}$ inch x $2\frac{1}{2}$ inches, of both oval and cupped points, will require about twenty linear feet of shelving, exclusive of vertical supports, the shelves to be placed the same distance apart as for machine screws.

While the set screws average larger than the machine screws there are only fifty in a package, against one hundred and forty-four machine screws. Set screws with V-points, if they are of small sizes, may be kept in the original packages, but if of larger sizes, as for shafting hangers, they are best stored loose in bins. Gib screws, being of the smaller sizes, should be kept in packages or boxes. Round head and hexagon head cap screws of small sizes, say $\frac{1}{4}$ x 1 inch to 7-16 x $1\frac{3}{4}$ inch, should be kept in packages, on shelves, and will occupy about the same space as set screws. The larger sizes should be kept in bins holding about five hundred. In arranging shelf space for machine, cap, and set screws it is assumed that there will be at least three packages of each size on hand, which will be sufficient for all ordinary purposes. Special screws are usually made in large lots and are more conveniently kept in bins.

Belting may be placed under the bench at the end of the room. The rolls should be set on edge, between vertical supporting boards, and kept in place by a strip 3 inches high, placed on the floor in front of the rolls. In issuing belting the roll remains in place and the portion taken off is stretched along the floor and measured to the length required.

Miscellaneous hardware should be kept on shelves, and as it is seldom called for, the higher shelves will be the proper place.

Should the amount of purchased parts be larger in proportion than is

here arranged for, the door leading into the general office may be omitted, thus gaining room for one more case and making one more alcove, and a door be cut through into the hall from the space inside the rail. This would add about 15 to 20 per cent to the storage capacity of the room.

The desks provided in these rooms should be a fixed top about 44 inches from the floor. Twenty-four inches wide will be ample. The top should be inclined to the front about 1 inch to the foot. Drawers provided with locks are fitted under this top, and below the drawers should be three shelves 12 inches wide, the first 8 inches from the floor and the others 8 inches apart. These will be convenient for storing books, blanks, etc. The space under the counters should also contain similar shelves, but these should not contain articles of regular issue to the shop.

The stock used for building bins and cases should generally be $\frac{7}{8}$-inch pine. The divisions in the file case and in the sheet metal case need be only $\frac{1}{2}$ inch thick. It is well to paint all these fittings quite a light lead color, as it is a good wearing color, and should not be so dark as to interfere with ample light. The partitions may be of the same tint up to a line 5 feet above the floor, and above that, including the ceilings, white. The same colors will be proper for the tool-making department.

From the descriptions given in this work and the dimensions mentioned ordinary carpenters should be able to construct any of these fixtures in a creditable manner. The author has supervised the construction of every form shown herein and can testify to their convenience and efficiency as well as the economy of the construction shown and described.

CHAPTER XIX

THE DRAWING ROOM

Effective planning. Congenial surroundings. "The brain room." Proper design and furniture. Natural lighting. Artificial lighting. Location of the drawing room. The necessity for photographic facilities. Blueprinting facilities. Drawing tables. Chief draftsman's office. Desk for the chief draftsman. Filing case for drawings. Filing case for tracings. Filing case for blueprints. The dark room. The lavatory. The water-closets. The lockers. Plan of a drawing room with vault. Plan of offices on first floor when vaults are needed. The blueprint room. Blueprint frames and stands. Automatic washer for blueprints. Blueprint drying racks. The extension of drawing room facilities.

BRAINS are more important than hands; ideas are more sought after than things; the conception of that which we are to do, of that which we are to develop or to build, to produce and to sell, are first in the natural order of conducting all manufacturing operations, or of entering into any line of the world's trade and commerce. The *plan* is the first and important matter, and to plan well and wisely we must have the best ideas obtainable. These ideas and conceptions have many and far-reaching results and consequences, both as to a matter of mechanical and of financial success. Good ideas, properly developed and elaborated, may mean the beginning of years of business success to the owners or the promoters of the enterprise; while defective and ill-considered plans may mean practical ruin or thousands of dollars wasted in fruitless work.

But to plan well; to bring out the best ideas of the men whose duty in life is to study and think and plan the work that others are to perform, men should be placed in proper and congenial surroundings, which may inspire them to conceive and bring out the very best ideas of which they are capable, just as in any other line of human effort we make the conditions as favorable to success as we can if we are to expect good results.

The drawing room of the machine shop has often been facetiously called "the brain room," by those who have little conception of its real usefulness in the manufacturing establishment. Yet this is precisely what it should be, if it is properly organized, equipped, and has the right quality of men in its working force. And nowhere in the whole establishment is there more need

of men of original thought; of men with ability to "see the point," to grasp the situation and make practical use of ideas and suggestions as they present themselves; and to take apparently worthless plans or devices and develop them into that which is mechanically good and financially profitable.

These conditions making the drawing department one of the most important in the whole establishment, it naturally follows that in its location and equipment much thought and care should be exercised so that all the conditions and surroundings should be of the best, as to their kind and their adaptation to the particular class of product which the establishment is to turn out. By this we do not mean that the drawing room should be expensively or luxuriously fitted up. Its design may be comparatively plain and yet architecturally and artistically correct and agreeable. Its furniture may be simple and yet appropriate, and serve its purpose as well as that costing several times as much. Dark-colored woods should not be used, owing to the fact that their color absorbs so much light. We should choose, rather, light-colored woods such as oak, ash, birch, or even white pine varnished, according to the amount available for the work. The walls may be wainscoted or sheathed up to about the height of the tables, but above this line they should be finished with a plain, white surface. The ceilings should also be white. A hard finish of what the plasterers call "adamant" is very durable and may be rendered still more so by painting with oil paint, several coats of which should be put on, in preference to kalsomining.

The windows should extend from the height of the drawing tables entirely to the ceiling. They should be provided with two curtains, one reaching from the top of the window down to the center, and a second one reaching from the center down to the bottom. The men working directly in front of the windows should only handle the lower curtain; and those in the center of the room have charge of the upper curtain. The curtains should be white, or nearly so. Instead of curtains some prefer ribbed glass, as it does not admit a glaring light in any one place, but is very useful in diffusing the light over the whole room, and the appearance of the room is much better than where curtains are used. Some prefer plain glass for the lower portion of the window and ribbed glass for the upper portion.

Electricity is the favorite artificial light, and the incandescent lamp seems to be the proper one. The question of whether we shall use enough of these, placed high up, to flood the whole room with light, or have them low down and under the control of each individual, is still discussed with fairly good reasons on both sides. Probably a majority of draftsmen will prefer the individual lamps which they can place in any position best calculated to aid them in the particular kind of work in hand.

Some of the more important conditions in reference to the location and

construction of the drawing room are these: It should be away from the noise and bustle of the machine shop, yet near enough to make the latter readily accessible. It should be directly connected with the pattern shop as it is so intimately associated with it in many of the preliminary operations. It should be readily accessible from the offices. It should have plenty of fresh air and be well ventilated at all seasons of the year. In winter the heating system should be such as to maintain as even a temperature as possible. It should be well lighted, by natural light by day, and a proper artificial light during the hours which make it necessary. It should be provided with proper facilities for photographing machines, or any of the articles produced by the shops. It should have connected with it, but not installed in it, facilities for blueprinting, where an abundance of light is available at all hours of the day. It should be provided with proper facilities, not only for making drawings and tracings, but for indexing them, for issuing and receiving them, and for safely preserving them from fire or other injury. In the descriptive matter which follows and the drawings illustrating it, the effort has been made to meet all of these conditions in a practical and economical manner, and on such a plan as will provide drawings, tracings, blueprints, etc., for small or large plants, or for a large variety in the product to be manufactured; as will be pointed out in detail later on in this chapter.

In the drawings, Fig. 94 is a plan of the drawing room, located above the offices and well lighted by ten large windows, as shown. It is reached from the latter by a broad flight of stairs. Along the front are located the drawing tables, providing for eleven draftsmen. The arrangement is so made that three of the single or regular tables are for the draftsmen making the general drawings, their tables facing the windows. Between them the two double tables are placed, with their ends toward the windows. These tables accommodate four men each, who do the detail work and the tracings. The circles in front of the tables indicate the positions of the men.

The single drawing tables are shown in perspective in Fig. 95. These are of the plainest construction consistent with usefulness. The top inclines 1 inch to the foot, and is 3 by 6 feet, which is ample for most general drawing work. They may be made with vertical legs, but the crossed legs here shown are more rigid. Braces extend from the crossing of the legs to the center beneath the drawers, to support the top as well as to act as braces to insure stiffness. Foot rests are provided, 10 inches from the floor. The height of the tables in front is 37 inches. Three drawers are supplied for holding instruments, books, memoranda, etc. If preferred these tables may be constructed with vertical legs as shown in Fig. 96, if appearance is a point considered, as they will thus present a more symmetrical form. The cost will, of course, be somewhat greater.

Many more or less complicated forms of drawing tables, as well as other equipments for the drawing room, have been devised, described, illustrated, built, used, and in many cases discarded; and it has come to be the opinion of many of the older draftsmen that while each of the more complicated devices has its peculiar merits, the simpler forms are, in the long run, best adapted to every-day work. The double drawing tables are shown in Fig. 96. They are 6 feet by 10, and are the same height and inclination of top as the single tables. Three drawers are provided for each draftsman, and a con-

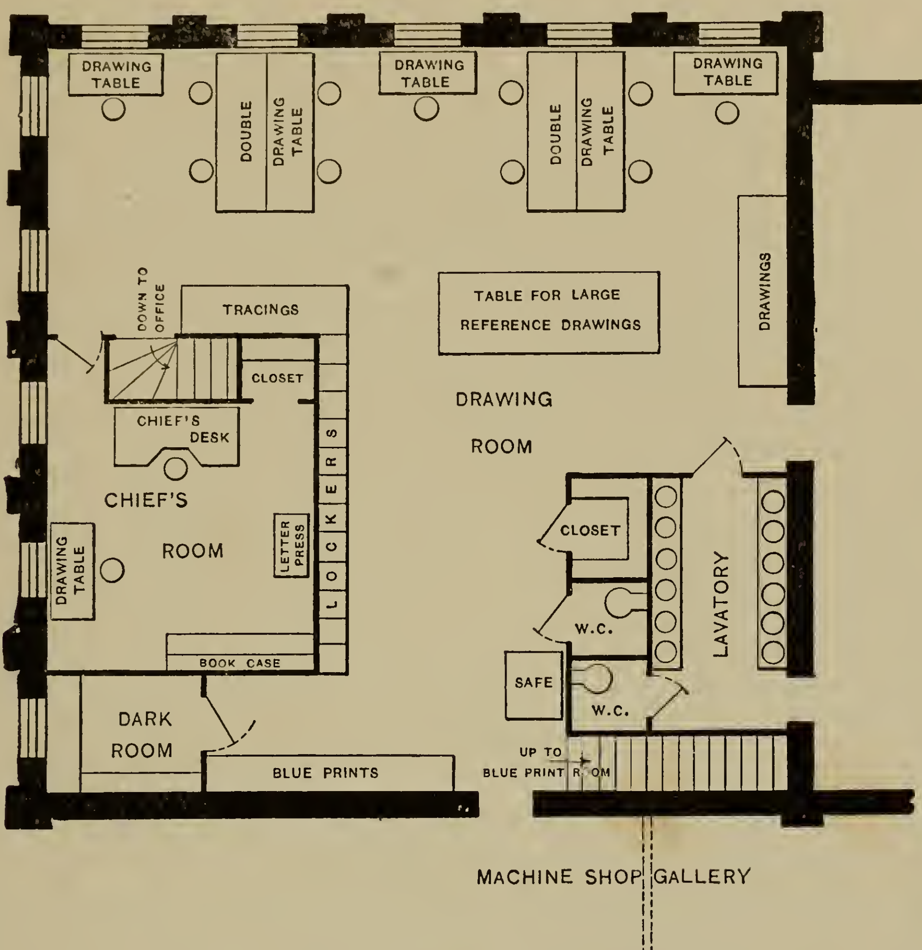


FIG. 94.— Plan of the Drawing Room and its Arrangement.

venient shelf is placed over the center, within the reach of all the men, for holding instruments and many small articles that it is desired to place out of hand but within reach. Foot rests are provided the same as in the single tables. These tables are of the proper height to permit the draftsmen either to sit or stand at their work, as a change of position is much easier than maintaining either one of these positions for hours at a time.

The chief draftsman has a separate room and he is provided with one draftsman whose duty will be that of working out special devices that come more particularly under the constant supervision of the chief. The desk of the chief is shown in Fig. 97, and is identical with one used several years by

the author and found to be a very useful and practical desk and drawing table combined. The top is 30 inches high and 34 inches wide by 6 feet long. The center of the top at the front is cut out in a semicircular or hexagonal form of a recess to enable the draftsman to sit in close to his work and at the same time to have ample table room at the right and left. Two boards drawing out under the top, one at each side, add to this space, so that a practically continuous table on three sides of the draftsman is provided. This

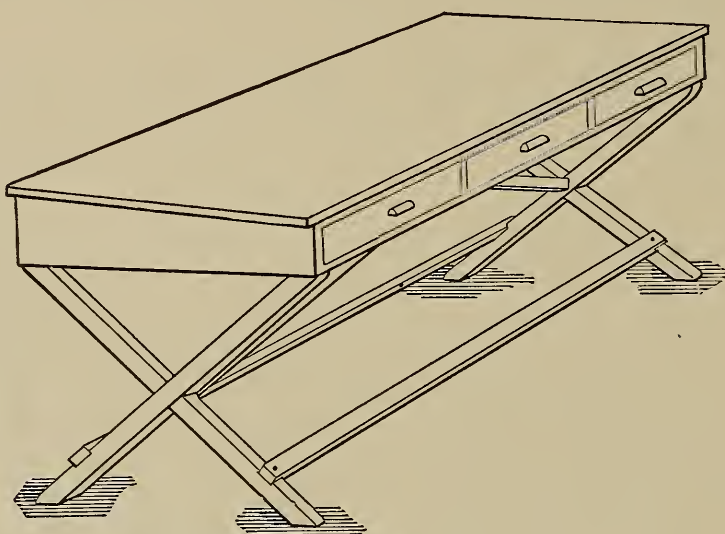


FIG. 95. — Drawing Table for one Draftsman.

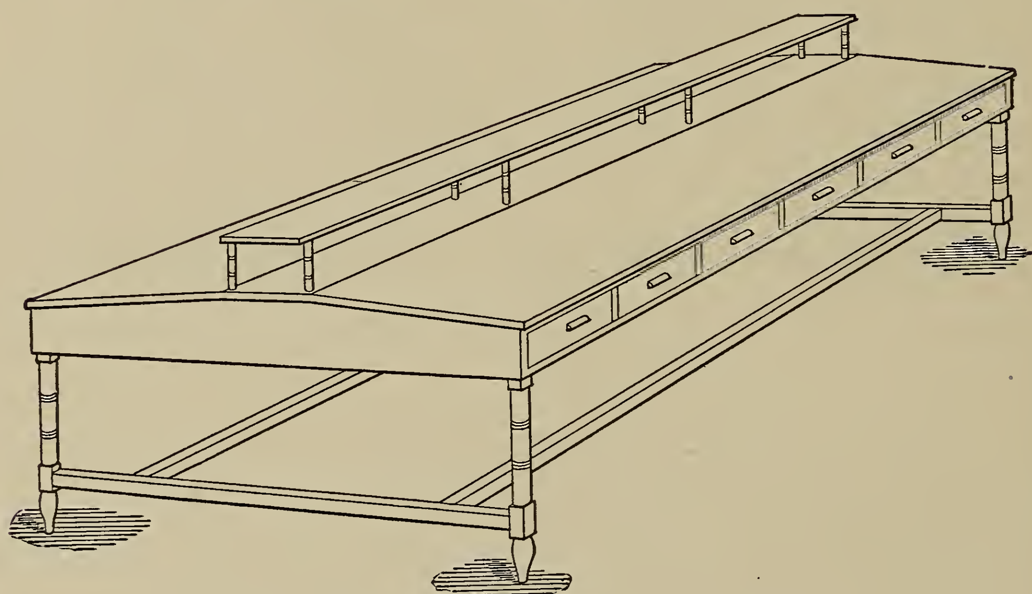


FIG. 96. — Double Drawing Table for Detail Draftsmen.

arrangement is very useful where many reference drawings, books, or catalogues are to be consulted. Four drawers on each side and one directly in front furnish ample filing space. A shelf at the back is convenient for books or for supporting instruments or other small articles not in use at the moment. The chief's room is provided with a convenient closet, and it has a table with drawers beneath and a bookcase above, as well as a letter-copying press for

making letter-press copies of sketches, memoranda, and similar matter sent into the shop or to those outside of it. The drawing table used by the chief's assistant is the same as the single tables in the large room.

In Fig. 98 is shown a very convenient filing case for drawings. It has drawers for general drawings and detail drawings, made of different sizes to suit their dimensions. These drawers should have a fixed horizontal strip,

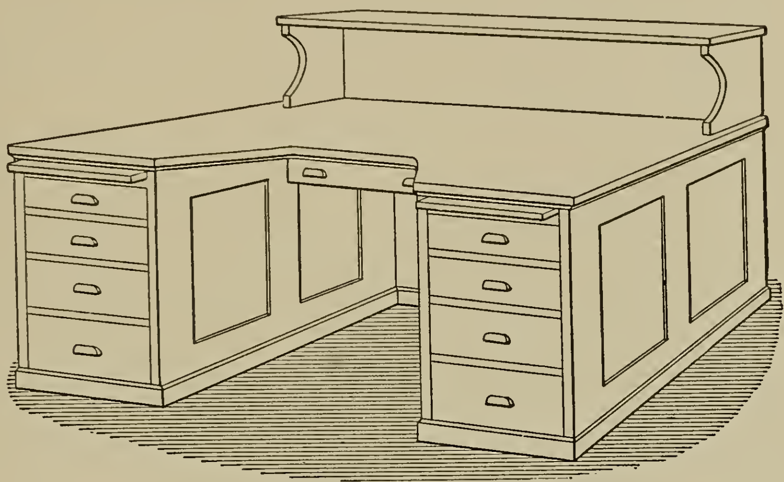


Fig. 97. — Chief Draftsman's Desk.

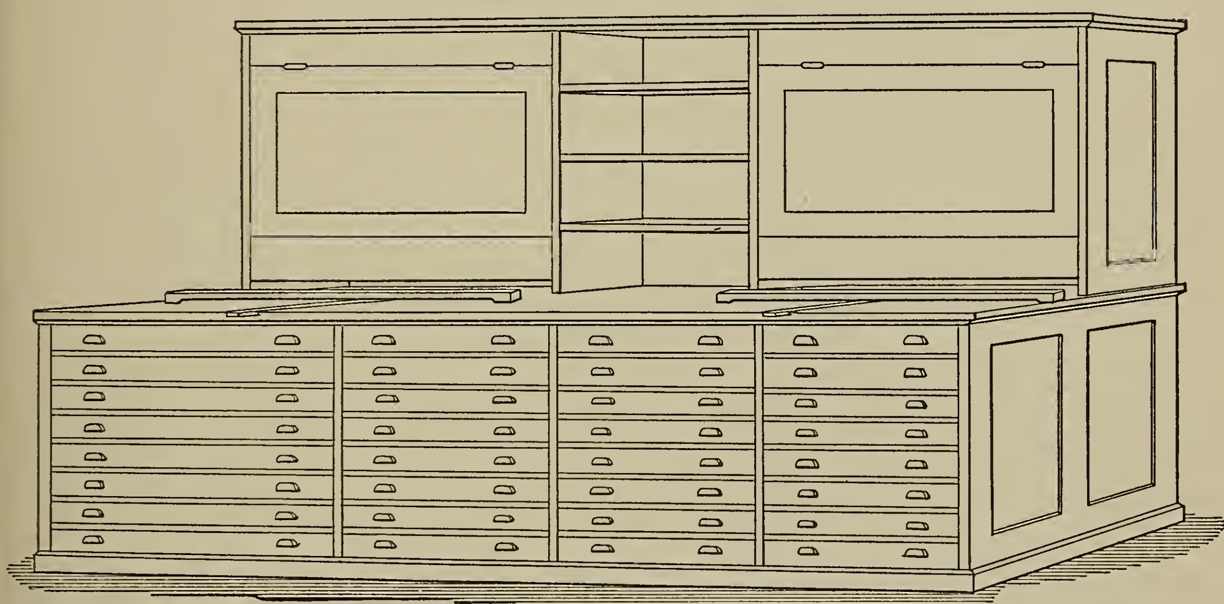


Fig. 98. — Case for Filing Drawings and Tracings.

say $\frac{3}{8}$-inch thick and 5 inches wide, running along the back of the drawer at the top, to prevent drawings from curling up and sliding over the back edge of the drawer. In the front part of the drawer a similar strip, pivoted, or hinged so as to turn down over the front edge of the drawings, or back out of the way when the drawings are to be examined, removed, or replaced, will be found very useful. In the center of the front, each drawer should have a

metal label holder, in which a lettered card, readily removed and changed when necessary, describes the contents of the drawer. Usually each drawer is devoted to the drawings of one machine. Above the table are two cases in which are to be kept rolls of drawing paper of different widths or qualities, tracing cloth, tracing paper, etc. Doors hinged at the top and provided with spring catches at the bottom afford convenient access. The ends of the rolls of paper are brought down at the back and out the front under a guide bar, as shown, and along a sliding scale-of-inches, let into the top covering the drawers, and by which any length or width of sheets are measured, and may be cut off with a knife guided by the guide bar.

So far as we know, this is the most practical and convenient method of keeping and cutting up drawing papers; and the plan of purchasing drawing paper in rolls and cutting it up into any desired size of sheets seems to be preferable to purchasing the paper in sheets of odd sizes and trimming it to

Fig. 99.— Case for Filing Blueprints.

the dimensions required. In the center, between the two drawing paper cases, are shelves for holding books, catalogues, etc. This case is located against the wall dividing the drawing room from the pattern shop, and convenient of access for the draftsmen.

At the opposite side of the room, and against the stationary partition, is the case for filing tracings; and against the wall next to the machine shop a similar case is used for finished blueprints. It is of the form shown in Fig. 99, and has drawers constructed in the same manner as those in the case for drawings shown in Fig. 98. It is built higher than the latter to increase its capacity, although, of course, it may contain any number of drawings required for the work.

Many systems for filing and preserving drawings, tracings, and blueprints have been devised, but here again simplicity will be found best in

practice, and by devoting one drawer to each machine, and properly indexing the drawings and tracings, the desired sheet may be quickly found, taken out, and replaced, with little disturbance to the others. Where the variety of the work makes it necessary to have a great number of classes it will be found that a more elaborate system is needed, but the plan proposed will be sufficient for a large majority of establishments. In filing tracings it is well to lay in a sheet of thin straw board between every ten or twelve tracings, or to divide the tracings of a machine into divisions representing the groups of parts of the machine, as, for instance, of a lathe, the headstock, tailstock, carriage, apron, etc. This helps to keep the tracings lying flat without wrinkles and aids in quickly finding the one needed.

Next to the chief's room a dark room is provided for photographic work, as every modern drawing room is expected to be able to make photographs of machinery and similar articles; and this branch of work should not be done in connection with blueprinting, owing to failures that may result from carelessness in handling the necessary chemicals.

In the opposite corner of the drawing room and next to the pattern shop is arranged a lavatory provided with twelve bowls for the use of the draftsmen and pattern makers. In connection with this are two water-closets, one of which opens out of the lavatory and is used by the pattern makers; the other opening from the drawing room is for the draftsmen's use. A large storage closet is included in the space devoted to the above purposes, and between this space and the rear wall is the stairway leading to the blueprint room above. A fire-proof safe of sufficient size should be provided for storing such records and original drawings of special devices as cannot be readily replaced, and such valuable papers as always accumulate in the drawing room.

In the central space of the room is a table 5 feet by 14, for large reference drawings and similar purposes. Drawers under this table are convenient for holding large construction sheets which cannot be filed in the regular cases without folding.

Against the partition of the chief's room is a row of lockers, one for each man. These should never be constructed of boards, or in any way tightly enclosed, but, as a matter of fire protection and sanitary cleanliness, should be open to a free circulation of air; and nothing which we have seen fulfils the conditions better, or perhaps as well, as what is generally known as the "expanded metal" used in many establishments for this purpose.

The above arrangement of the drawing room and its equipment is intended for cases where there does not seem to be the need of an expensive vault in which to store drawings, tracings, blueprints, etc. Still the want of this means of safety to such valuable records in case of fire has of late years been gaining in importance and would seem, in most cases perhaps, a good invest-

ment from the point of view of insurance. Hence an arrangement of the plans of both offices and drawing room has been made with this end in view, and is shown in Figs. 100 and 101. As a matter of economy the vault is built in a corner of the structure, the walls of which form two of its sides. For this purpose the superintendent's public and private offices are placed next to each other and the lavatory located between the latter and the vault, while the stairway leading to the drawing room is placed between the hall and the Purchased Parts Storeroom. This permits the vault in the drawing room to be built directly over the one in the offices and next to the chief's room, out of which it opens, without disarranging the plans to any considerable extent.

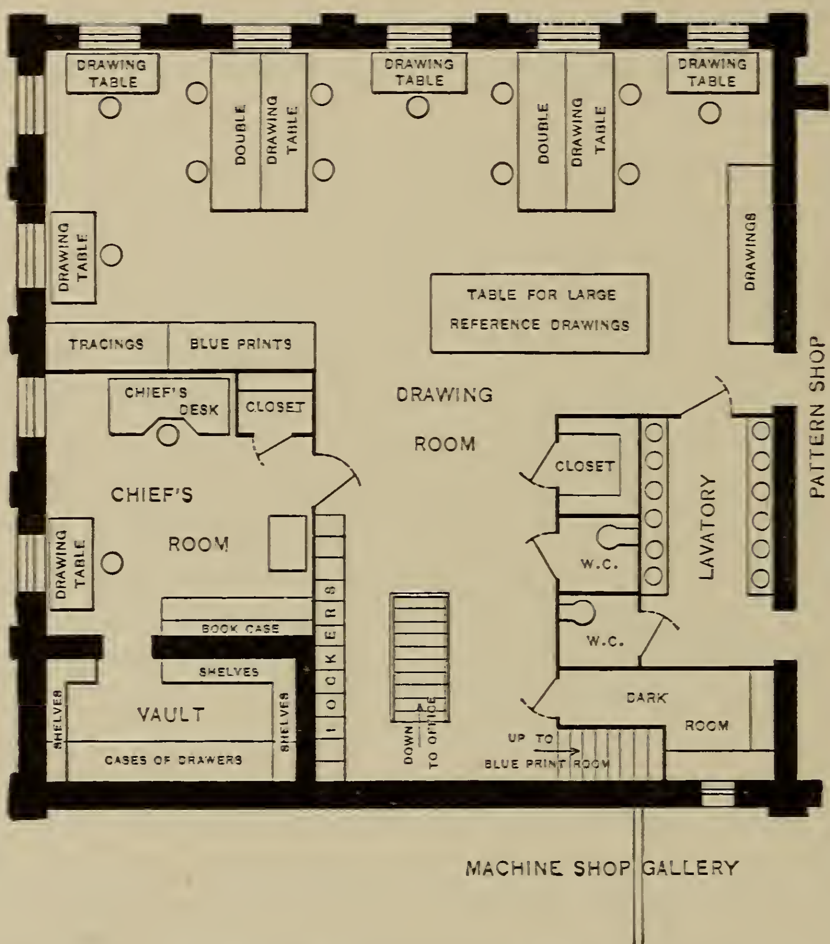


FIG. 100. — Drawing Room Arranged for Storage Vault in one Corner

The dark room is placed under the stairs leading to the blueprint room. The vault is provided with cases of drawers similar to those in the drawing room, and with racks for holding negatives, as well as shelves upon which may be stored any valuable records, memoranda, and similar articles. These vaults are 8 feet wide and 16 feet long, and have masonry floors and brick arches overhead. The walls should be 16 inches thick, exclusive of an air space of $1\frac{1}{2}$ inches in the center of the walls. Steel should not be used in their construction unless it is completely covered by brickwork, on account of its tendency

to warp from the excessive heat of a fire. Double fire-proof doors should be provided, similar to those used in safes. The hinges should be held by bolts passing entirely through the walls, as should also be the case with bolts securing the door frames.

The blueprint room is located in the monitor roof in the center of the building, and thus over both the drawing room and the pattern shop. The space available is 18 feet wide. It is well lighted along one side and across the front end. In it are built a large dark room and other facilities and appliances

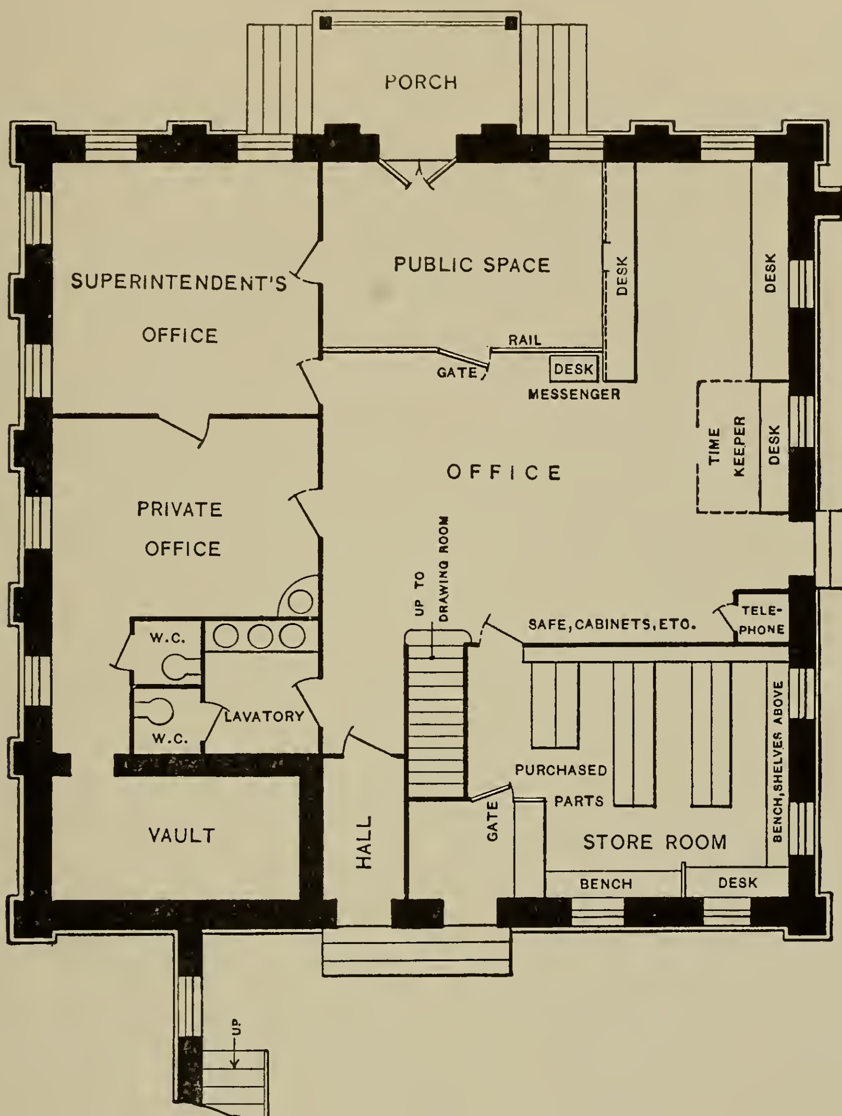


Fig. 101. — Arrangement of Offices under Drawing Room where there is a Vault.

for print washing and drying, as is shown in Fig. 102. The blueprint frames are opened and filled in the dark room and the smaller ones carried out the door to a platform built over the roof and on a level with the floor of the blueprint room. Instead of being supported by any kind of a rack, they are placed upon an adjustable blueprinting stand, as shown in Figs. 103 and 104. This may be easily turned to face the sun and the supporting board adjusted

to whatever altitude the sun may happen to be at the time. The stand is made with a cast iron standard rising from the base which is supported on three caster wheels of not less than 3 inches in diameter. A cast iron support

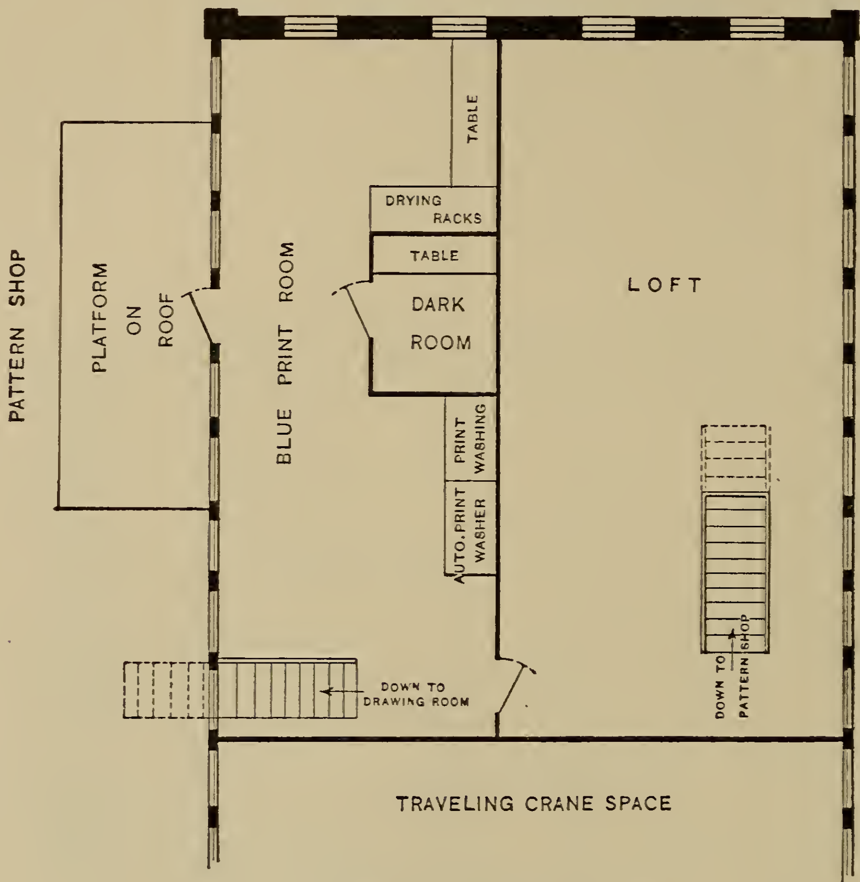
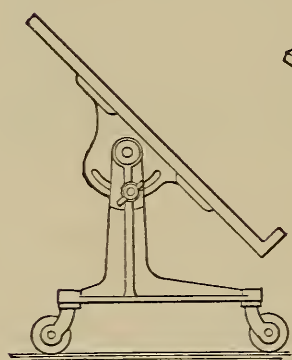


FIG. 102. — Plan of the Blueprint Room.



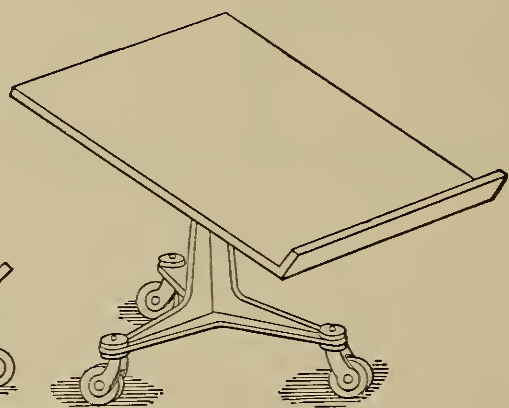


FIG. 103. — Side Elevation. FIG. 104. — Perspective View.
Stand for Supporting Blueprint Frame.

is pivoted between jaws formed in the standard, to which it is clamped in any desired position by a bolt and hand nut, as shown in Fig. 103. The board is attached to this support. When in the room the board may be brought to a nearly vertical position, thereby occupying less space. These stands may be kept in the room and the boards placed upon them and rolled out

on the platform, if heavy printing frames are used, but this is not usually necessary.

Fig. 105 shows a device for supporting large printing frames. This rests on four caster wheels of not less than 4 inches in diameter. Trunnions are fixed on the sides of the printing frame in a position to exactly balance it, and either the collars of these trunnions should press tightly against the standards, or the trunnions should be considerably larger than those shown, so that the friction will hold the frame in any desired position for printing. The printing frame may be held in a horizontal position for filling by means of the rod pivoted at one end of the frame and having at the other a hook formed upon it which engages a staple in the end of the frame. When in use this frame is rolled to the door of the dark room, the tracing and blueprint paper put in, closed up, and rolled out on the platform, thus avoiding much of the usual manual labor in carrying heavy printing frames.

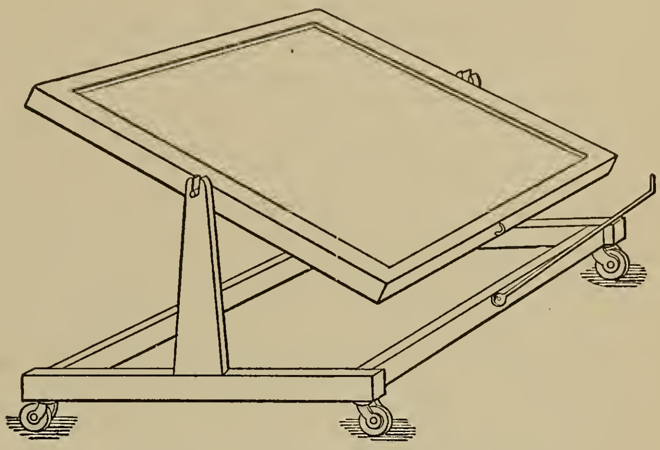


FIG. 105. — Large Blueprint Frame.

Where printing must be done out of a window various forms of tracks and frames must be resorted to, but there are many advantages in so locating the blueprint room as to utilize the roof for supporting a large, level platform, as here described. In cases where no monitor roof or similar facilities are offered, and the roof is nearly level, or with a slight pitch, it will be best to build a printing room on the roof with a platform outside of it, so as to be operated as here described.

A simple washing box is provided for soaking blueprints in the usual way. Also, an automatic print washer, as shown in Figs. 106 and 107. In this device a fixed box has pivoted in it a smaller box, whose bottom is composed of light slats. Upon this box is attached, but so as to be removable, a smaller box with a perforated bottom and divided by a transverse partition set exactly in the center. The operation of the device is as follows: The top box being removed by turning the buttons securing it, the blueprints are laid upon the slats, as many as six or eight at a time, and the top box replaced. The water is turned on at the faucet and one end of the pivoted box is depressed to either of the positions shown by dotted lines in Fig. 107, which will throw the water into the compartment at the higher end of the smallest box. A considerable portion of the water will trickle through the small holes of the top box and upon the blueprints, while the opposite ends of the prints are

immersed in the water of the lower box, which is maintained at a constant height by the overflow pipe, as shown in Fig. 107. The perforations in the bottom of the top box not being sufficient to carry off all the water, it gradually fills up that compartment and the pivoted box, thus weighted, is depressed, and the water from the faucets flows into the other compartment and the operation is repeated. The frequency of this rocking movement is easily regulated by the amount of water that flows from the faucet. The operation is not only entirely automatic, but very thorough in its action, as the prints

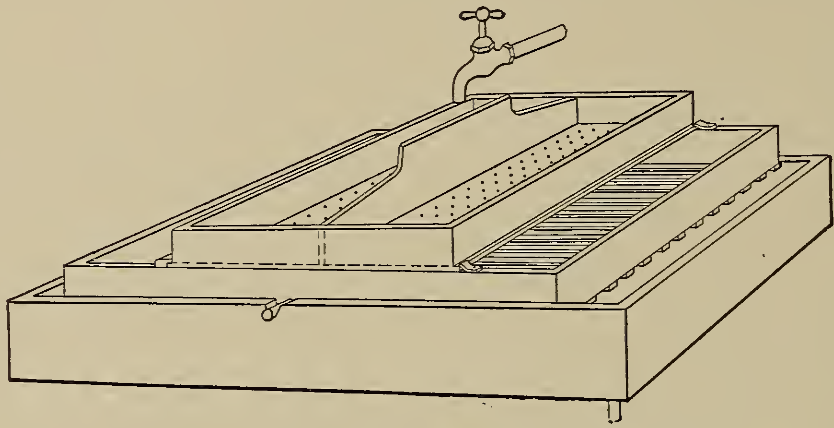


FIG. 106. — Automatic Washer for Blueprints.

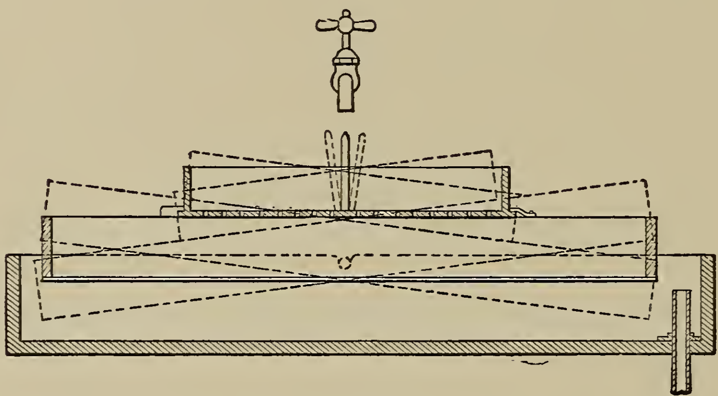


FIG. 107. —Longitudinal Section of Automatic Washer.

lying upon each other are separated and the upper ones float whenever that end is depressed into the water. The water constantly flowing in and out of the lower box readily eliminates the chemicals that are to be washed out of the prints. So far as he knows, the author originated this method for washing blueprints and photograph prints, and used it with much satisfaction. The boxes may be made of wood and kept well painted; or may be of galvanized iron or zinc protected by paint. The original one was made of white pine, the lower box of $1\frac{1}{4}$-inch, the pivoted box of $\frac{7}{8}$-inch and the top one of $\frac{1}{2}$-inch stuff, and painted with white lead.

For drying blueprints various devices have been used, but so far as the author knows, nothing is more economical or better adapted to the purpose

than the drying case, or cabinet, shown in Fig. 108. The plan is to attach the blueprints to small, round sticks by means of small wooden spring clips and hang them on supporting brackets. The brackets are of light cast iron or wood, as may be preferred, and should incline on an angle of 45 degrees, so that any print may be conveniently reached and removed without removing those in front of it. Two pairs of these brackets are located, one above the other, for medium sized prints, say 18 x 24 inches, as on the left of the engraving, or one pair for large prints, as shown on the right. The upper section of prints drip the water into a zinc tray supported by a wooden shelf fixed at an angle of 45 degrees, from the lower corner of which, at the back,

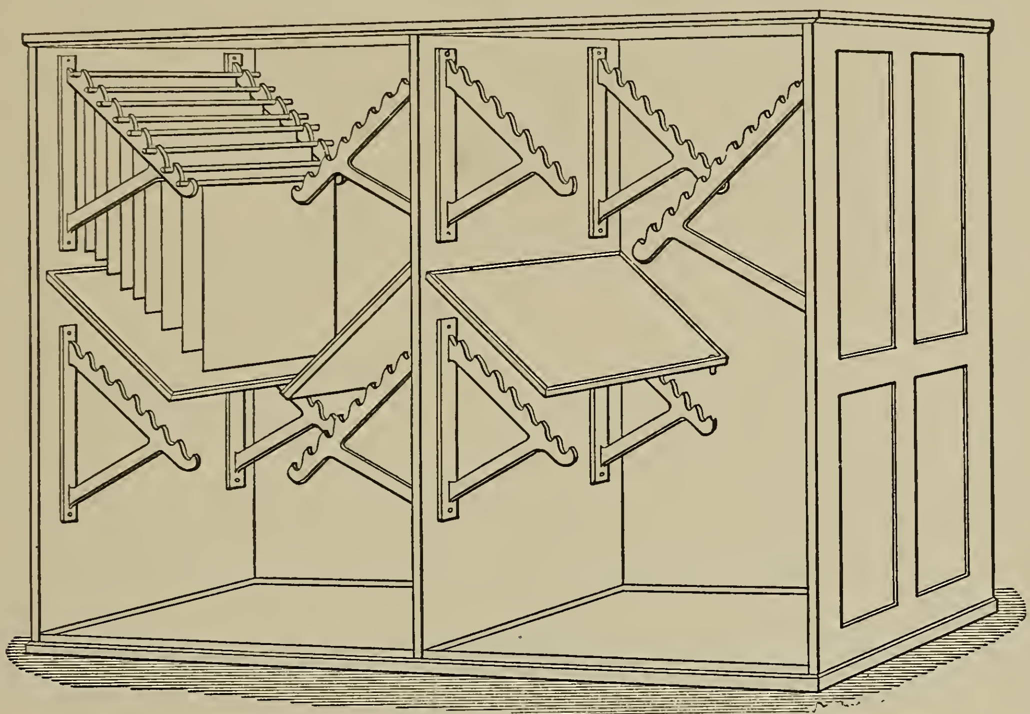


Fig. 108. — Blueprint Drying Racks and Cabinet.

a short pipe carries the water into a similar tray resting on the floor, and from which suitable pipes carry the water to the waste pipes coming from the print-washing apparatus. The drying of blueprints may, of course, be hastened by the application of artificial heat. For this purpose doors may be added to the drying case and a small steam coil be placed in the bottom or near the back of the case. But to use artificial heat, or any temperature over about 100 degrees, has a tendency to cause the prints to be distorted by unequal shrinkage, and marred by wrinkles, while drying them by the natural temperature of the room, and suspended as in this case, will cause them to come out in good condition.

In some large establishments blueprints are made by exposing the blueprint paper and tracing to the action of the light from an electric arc lamp located within a metallic cylinder, in which the paper is fixed, and by

means of which excellent blueprints may be made in large numbers without the aid of sunlight. While the first cost is considerable the work is done very expeditiously and economically, as the cost of labor is very much reduced. The quality of the work is good, as the lighting is very uniformly distributed over the surface of the sensitized paper.

To adapt this plan of construction and equipping a drawing room to the wants of larger establishments requiring a larger force of draftsmen it is only necessary to extend its length so as to provide for a greater number of the single and double drawing tables, to any extent required. The capacity for filing drawings, tracings, and blueprints should be increased in proportion. One or more large tables for reference drawings will be needed, and the number of lockers increased to accommodate the added force of draftsmen. Otherwise the same arrangement of the plan need not be disturbed, as the chief's room, photographic dark room, vault, and all the other accessories will be either ample or very easily adapted to an increase to any reasonable extent that may be desired.

CHAPTER XX

THE PATTERN SHOP AND PATTERN STORAGE ROOM

Location in relation to the drawing room and machine shop. Capacity of the pattern shop. The working force necessary. Nature of the product. Equipment of the pattern shop. Location of the machines. Building up segment work. The segment press. The faceplate lathe. The foreman's office. The surface plate. Pattern maker's benches. The work table. The varnishing bench and table. The lockers. The lumber loft over the pattern shop. The lumber drying room. The pattern storage room. System of storing patterns. Pattern storage racks of iron construction. The same of all wood construction. Double width storage racks. Step ladders.

NEXT to the drawing room, in the usual order of the production of new machines and the development of new plans and ideas into their practical form for commercial purposes, comes the pattern shop, with its proper equipment of woodworking machines, its work benches for the expert workmen, and the conveniences for those associated with them in getting out dimension lumber, and other similar work in connection with it; and closely allied with this department, and really forming a part of it is the pattern storage room, wherein patterns may be properly catalogued, stored, and issued to the foundry as occasion may require.

In the pattern shop proper the designs of the draftsmen are first brought into tangible form as patterns for the production of those parts to be made of that most common of all materials used in modern construction, namely, cast iron, as well as those for brass, malleable iron, and steel castings.

It is proper, therefore, as well as convenient, that the pattern shop should be placed next to the drawing room. In this case it opens out of it, and has also its convenient passageway to the machine shop by way of a wide door opening upon the machine shop gallery, which, being reached by the large traveling crane, affords a ready means for moving any heavy or bulky articles to and from the pattern shop as readily as to any part of the machine shop.

The pattern shop occupies the space over the tool room and storeroom portions of one of the 50-foot square structures, and extends, also, over the space taken up by the main driveway on the ground floor. It is thus 50 by 70 feet, affording ample space for all the ordinary uses of this department.

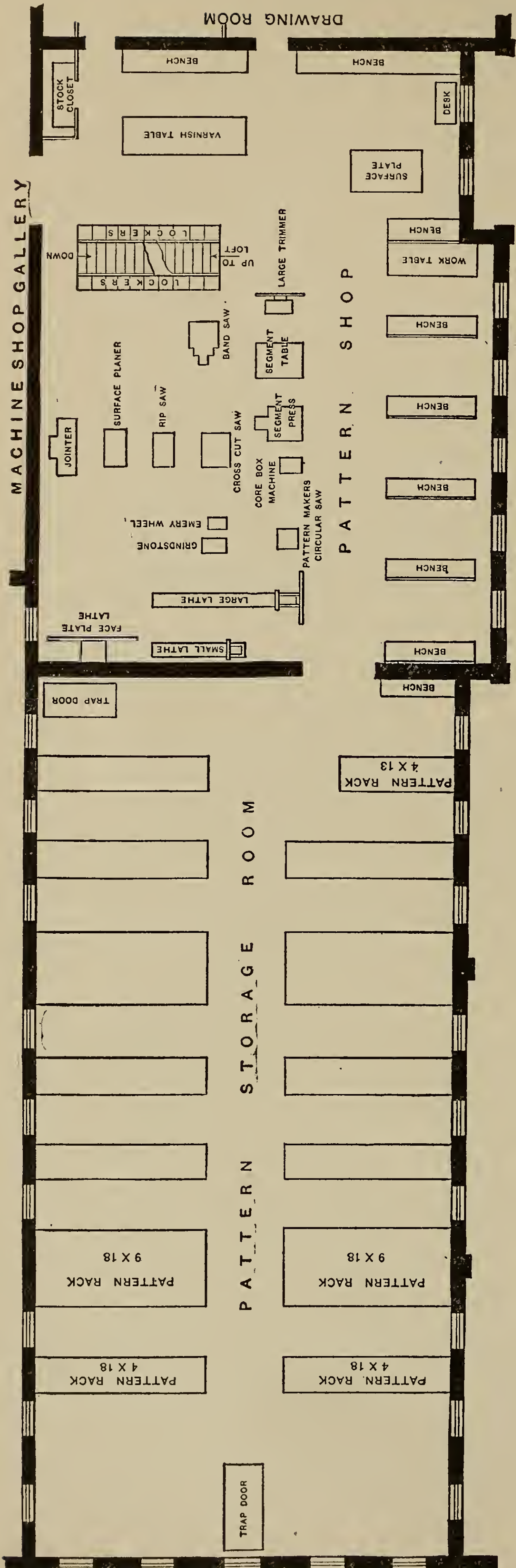


FIG. 109. — Plan of Pattern Shop and Pattern Storage Room.

In Fig. 109 is shown the plan of the pattern shop and the pattern storage room, and the location of the tools, machines, benches, and other fixtures therein, as well as those in the pattern storage room, giving the location of the pattern storage racks, and the trap doors, one of which opens over the storage space in the yard and the other over the flask room of the foundry.

As to the capacity of the pattern shop and the number of workmen who may be employed in it to advantage, assuming that the arrangement is in force of having special men for special work, there may be fourteen men as its regular force. These will be divided as follows, namely, one foreman, six regular pattern makers, one man at the lathes, one man at the planers, one man for the rip saw and the cutting-off saw, one man at the band saw and for building up segment work, one man at the varnish bench for varnishing patterns, and one man to letter and keep a record of patterns, and one general laborer.

If the product of the shop is in a regular line where nearly the same work is turned out year after year, we have only to provide for the necessary changes of patterns due to the usual changes of form and style that may be required by the

demands of trade. In this case the force above provided for could well be considerably reduced. If the product of the establishment is of such a nature that improvements, both in the work turned out and also in the tools necessary to accomplish that result, are constantly in progress, the force above specified will not be too great. If the product is such that a majority of the orders are for such machines as have to be made special, or with important features specialized to meet individual cases, then the force described above may not be sufficient to maintain an evenly balanced arrangement and division of the working force of the establishment.

Where the latter condition is found it may be necessary to use a portion of the pattern storage room adjoining the pattern shop, and well lighted for such use, should it become necessary.

The equipment of the pattern shop has been carefully worked out, with the end constantly in view of so arranging the available space and of so equipping it with such woodworking machinery as may be necessary to carry out the plan of keeping the skilled pattern makers constantly at work on that which is essentially pattern work, and requiring a man skilled in that vocation, rather than of allowing them to use their time in getting out dimension lumber, varnishing patterns, and similar work, which may be just as well done by men of less ability and a lower rate of wages.

Consequently the machines, such as surface planer, jointer, rip saw, cutting-off saw, etc., are handled by men who are practically "mill men" who, while they know little or nothing about pattern making, are capable of getting out such dimension lumber as may be called for by the pattern makers in much less time and at less cost than if it were done by the pattern maker himself. So it is with the man who handles the band saw, whose principal work is that of cutting out segments for the building up of the rims of wheels, gears, etc. Being constantly at this particular kind of work, the man need not be a skilled pattern maker and yet can exceed one in the output and the economy of doing this class of work. In the same manner, for varnishing of new patterns and the revarnishing of old ones, a pattern maker is not needed. Neither is it necessary to employ one to mark, letter, arrange, and catalogue the patterns when completed, as this work may be just as well and much more economically done by a special man at a less rate of wages.

The equipment of machinery and fixtures for the pattern shop, and the location selected for them to insure convenience of their operation and of the handling of stock and product without unnecessary labor, is fully shown in the general plan in Fig. 109, and is as follows: Next to the machine shop wall is placed a jointing planer, provided with the usual guides and gages by which the various angles or bevels may be cut upon any length of stock up to 16 feet. Beside this is an ordinary surfacing planer capable of taking in

24 inches in width and, also, 16 feet in length. Upon the jointing planer stuff may be planed "out-of-wind," and then passed to the surfacing planer for reducing it to an even thickness. If much large work is to be made where large and perfectly true surfaces are necessary to be obtained, it will be advisable to have a Daniels, or vertical planer, to which this stuff is first taken. From the surface planer the stuff passes to the rip saw, and from there to the cutting-off or cross-cut saw. In many cases it must be passed back to the jointer to be finished on the edges.

Shop trucks with proper racks should be provided, upon which the lumber may be placed, so that unnecessary handling or carrying may be avoided.

Next to the segment press is a core-box machine, which is a very convenient, if not almost indispensable, machine where many boxes for round cores are to be made, as it accomplishes the work in a fraction of the time required to do it by hand.

Next to the core-box machine is a special pattern maker's circular saw bench, which is so arranged as to carry both rip saw and cutting-off saw, either of which may be brought into use as needed; and a table capable of being set at any desirable angle. The table is provided with guides and gages for cutting any angle wanted. This saw is of special value in pattern-shop work, and saves much hand labor, even in cutting out the quite small parts of patterns. The Colburn universal saw table is an excellent example of this class of machine.

As a large part of pattern making often consists in laying up segment work, special provision is made for it. From the planers the stuff is taken to the segment table, laid out, then to the band saw where it is cut into segments, from whence it goes to the trimmer, the ends are cut and the segments are fitted into circles on a wooden faceplate. This plate has formed on its under side a recess which fits over the iron faceplate of the lathe. A circle of these segments having been fitted together, they are glued at the ends and small steel dogs inserted to hold them. Another circle is formed and glued at the ends and to the first segment, the dogs being placed in the edges, out of the way, and the whole placed in the segment press, which holds it firmly until the glue has set; and so on until the job has been completely laid up. It is convenient to have two faceplates to work on alternately, as one may be in the press while an additional circle of segments is being fitted to the other.

The segment press is of the vertical type, and may be constructed with a large screw acting upon a follower, or it may be built similar to a Greenerd arbor press with a rack and pinion arrangement. A convenient form is one with a vertical screw having fixed to its upper end a large worm-wheel

which engages a worm upon a horizontal shaft, which extends to one side of the press, where a hand wheel is attached to it for convenience of operating. With this arrangement segments may be made and laid up in much less time than where hand clamps are used and applied as each segment is laid on, while the evenly distributed pressure insures good contact of all the pieces. They may be nailed, or not, as desired.

For small turned work a wood lathe to swing 18 inches, and with a 10-foot bed, is provided. For larger work a lathe of 30 inches swing and with a 16-foot bed will be a good size. Both should be provided with slide rests, and the larger one with a faceplate on the back end of the spindle for turning large work from a floor rest. When much larger faceplate work is called for, a faceplate head is needed, and one is located near the rear wall and in line with a rear window. This head carries a faceplate capable of swinging 10 feet. In front of this may be arranged a compound rest, supported by a pedestal, and capable of covering the turning, inside and out, and of facing the largest work to be done.

Near the lathes the grindstone and the emery wheel are located. The latter should be provided with wheels of different form for grinding the various shapes and sizes of gouges and similar tools in use.

The foreman's corner is next to the drawing room, so as to be in convenient communication with that department. He has a bench, more as an occasional convenience than for regular use, and a desk, as a necessary part of his equipment, as he has various books, blanks, reports, etc., to handle, and as a matter of efficiency and economy of time should have all the necessary conveniences for doing this part of his work.

The first pattern maker from him has, in addition to the regular equipment, the use of a cast iron surface plate, say 5 by 8 feet, its dimensions regulated, of course, by the kind of work to be done. This is an indispensable convenience in building up many of the more complicated patterns, and there should be at least one in every pattern shop.

The pattern maker's bench is shown in perspective in Fig. 110. The top is 30 inches wide and 10 feet long. It stands 34 inches high. It is composed of hard maple at the front, 12 inches wide, and the rear portion of white pine, both $2\frac{1}{2}$ inches thick. It is supported on three cast iron bench legs, the front feet of which are set back 5 or 6 inches, so as to be out of the way of the pattern maker's feet. The upper 16 inches of these legs have a facing of hard maple, that on the center and rear legs having holes for the introduction of pins for supporting long work when held on edge. Four drawers, with flush pulls, are placed in a case under the rear portion of the bench, for holding small tools, files, and a variety of similar articles found necessary by every pattern maker.

At the rear end of the bench is formed a compartment under the bench for holding short pieces of hard wood stock, dowel pins, and similar materials. At the head of the bench is located an Emmert universal vise,

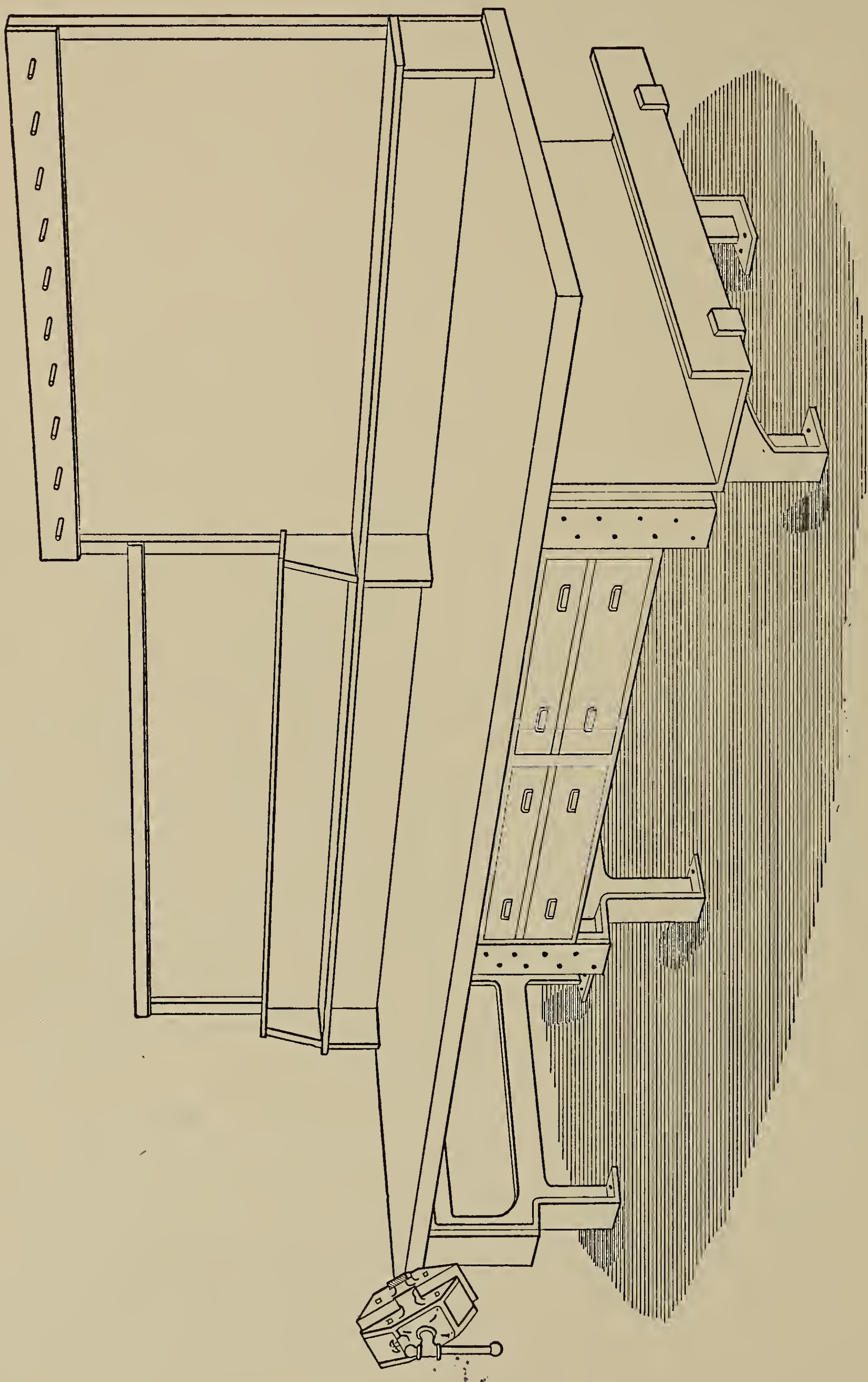


FIG. 110. — Pattern makers' Bench.

which seems to be the best device yet put on the market for this purpose, as it may be placed in almost any position convenient to the workman, and will hold a piece of almost any form with equal facility. At the back of the

bench is a shelf or tool rack extending the whole length, and at a proper height above it is one extending one half the length. These are to be properly perforated for the reception of the ordinary tools of the pattern maker, such as his chisels, gouges, auger bits, twist bits and drills, screw drivers, and all similar tools. Over this short tool rack the backboard is extended up to a light rail, so as to provide a space for hanging larger tools, such as bit-stocks, back saws, and tools of this nature. At the back of the rear half is an open frame whose top bar is provided with pins for hanging large saws and similar articles. If the kind of work renders it necessary a bench trimmer should be attached at the rear end. This style of a bench is at once rigid and substantial, does not occupy unnecessary floor space, is compact and complete in all its arrangements, and for a first-class bench it is economical in cost.

These benches are arranged with the head toward the wall and two feet from it, so that private tool boxes or cupboards may be conveniently arranged upon it. Their positions are clearly shown in the plan.

A large work table is provided for the second pattern maker, and one should be provided for the others when the nature of their work requires it. It may be placed either between the benches, or near their rear end, as may be most convenient.

It will be noticed that the benches and machines are so arranged that they leave a broad alley through the shop, and to the door leading to the machine shop gallery.

There is a regular wall bench and a large center table provided for the varnisher and the workman having charge of the marking, numbering, and cataloguing of the patterns. From this point they may be taken on properly-arranged platform trucks, to the pattern storage room, or to the foundry, as the case may require.

At each side of the stairs leading to the loft the individual lockers for the use of the men are arranged. These are of the expanded metal type, as built by Merritt & Co., or of some very similar material and construction, but never of boards, or any construction which excludes thorough ventilation and safety from fire.

The stairs just mentioned lead to the loft shown in the plan in Fig. 111 and in which is constructed a lumber drying room, as laid out in the plan and shown in interior perspective in Fig. 112. This room is tightly closed by double sheathing on the top, the back, and both sides. The front is closed by three sliding doors, arranged to pass each other, so that any portion of the front may be opened for the purpose of putting in or taking out lumber. The lumber racks are of wood construction, the posts being 4 x 5 inches, the two lower horizontal timbers 3 x 6 inches; the next two are 3 x 5 inches, and the upper three are 3 x 4 inches. These timbers should be firmly bolted

together and to the sides of the room by through and through bolts, as there will necessarily be much shrinking of the timbers, and consequently no nails should be used. The sheathing may be put on vertically or horizontally, as preferred, but both thicknesses should run the same direction, and should break joints. The studding or timber work supporting the sheathing should not be over three feet apart, in the direction of the length of the sheathing.

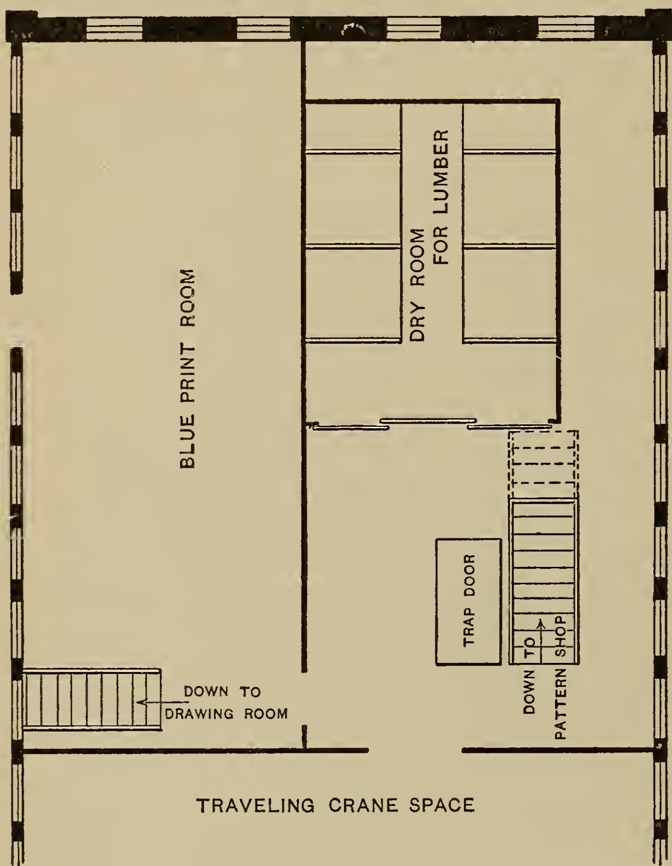


Fig. 111. — Plan of Loft over Pattern Shop.

In the drawing, Fig. 112, only the front frame is shown on the left of the room, to avoid a confusion of lines, as the form and location is fully shown on the opposite side. The frames should be placed seven feet apart, so as to accommodate lumber from 8 to 18 feet in length. The lumber is placed on edge, supported by three racks or frames of this kind, and held in place by round iron rods, $\frac{5}{8}$-inch for the three lower sections, and $\frac{1}{2}$-inch for the three upper sections. These rods should be placed five inches apart in the lower section, four inches in the second, three and one quarter inches in the third, two and one quarter inches in the fourth, one and three quarter inches in the fifth, and one inch in the sixth, from center to center. The distance apart, in the clear, for the horizontal supports, should be eighteen inches for the lower four spaces, and sixteen inches for the upper two spaces, if lumber of the ordinary widths is to be used.

Heat may be applied by a steam coil as shown in Fig. 112, or hot air may be admitted from the regular air pipes of the heating system. The degree of heat should not be high as the seasoning process is apt to be too much hurried and so produce an unnecessary number of "season checks" by drying and consequently shrinking the outer portion of the lumber before the center has the opportunity to contract with it. Some have advocated the plan of standing the lumber on end, and then turning it "end for end" once a week. This causes an unnecessary amount of labor. If the lumber is placed in the racks as shown, it will not be necessary to even turn it over,

provided too high a temperature is not maintained. The necessity for a dry room is apparent from the fact that it is very difficult to obtain properly kiln-dried lumber fit to put into pattern work, whatever price we are willing to pay for it. And unless we dry it ourselves we are never sure of its condition. Patterns are too expensive to take any chances of improperly seasoned lumber.

For convenience in passing lumber to and from the dry room, a trap door, as shown in Fig. 111, may be made in the floor of the loft. Pattern lumber may be delivered on the machine shop floor, passed to the gallery by the traveling crane, then up through this trap door to the dry room. After

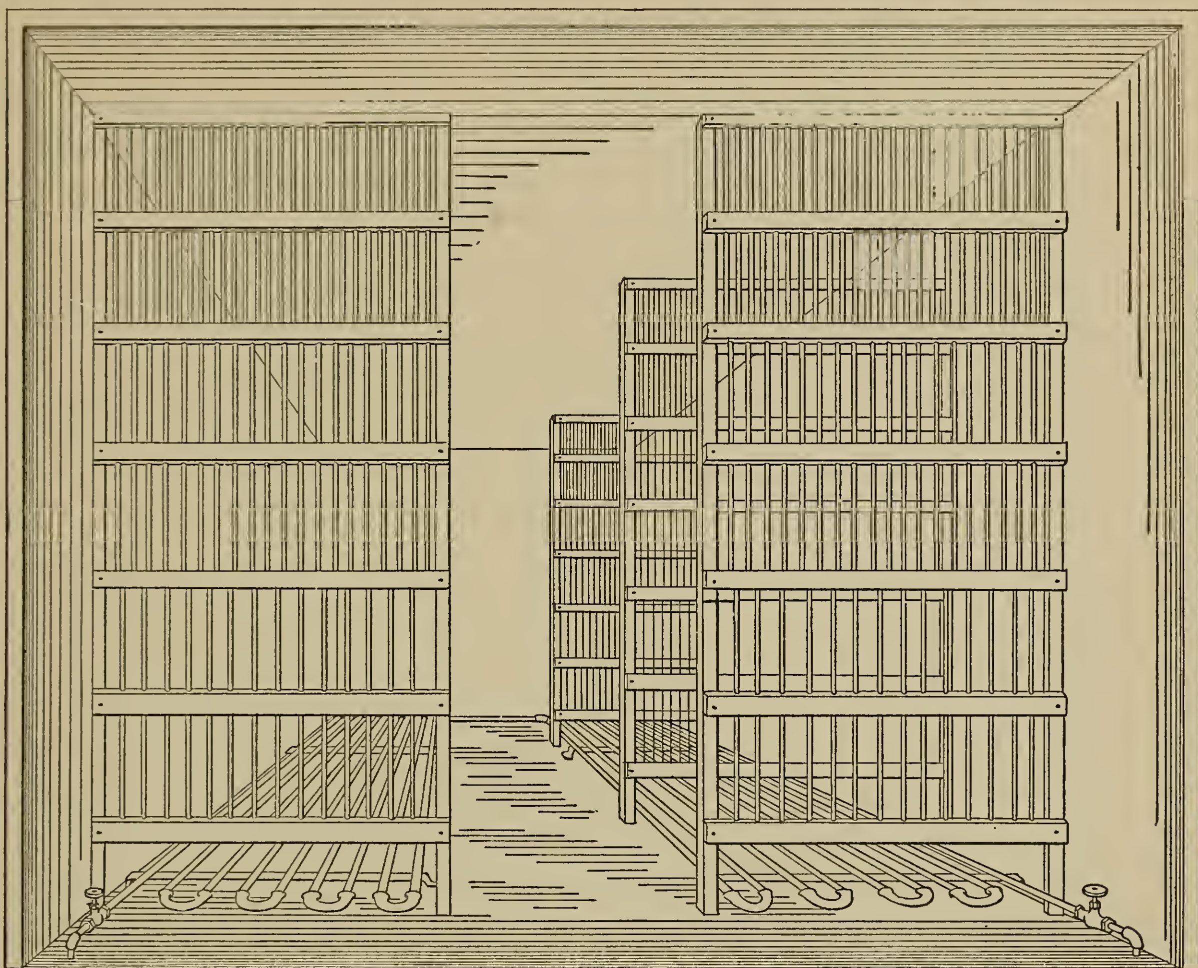


Fig. 112. — Dry Room for Pattern Lumber.

it is properly dried, it may be passed back to the pattern shop in the same way. Or, it may be passed in through the trap door over the pig iron storage space, and thence into the pattern shop.

The pattern storage room is a continuation of the pattern shop, a door 8 feet wide giving ample access to it. In the inner corner, next to the pattern shop, is a trap door 4 feet by 8, opening over the pig iron storage space, and at the other end of the room is a trap door 4 x 10 feet, opening over the flask room of the foundry. Over this trap door is a quick-acting hoist by which patterns may be readily lowered to the foundry, or brought

back to the pattern storage room. This room is amply lighted so that patterns may be easily found, stored, or taken from the shelves as needed.

The system of storing patterns is upon a series of shelves arranged so as to form alcoves connecting with a wide passageway in the center, the pattern racks being placed with the end against the wall, and regularly between the windows. Opposite the broad spaces in the walls where the pilasters are located, and space between windows is wider, the pattern racks are made of double width, and are used for the storage of larger patterns, which may be more conveniently stored on very broad shelves. Should the patterns be generally of small size, so as to make narrower shelves advisable, the racks may be all made of single width and located without regard to the windows. In this case they are placed two feet from the wall. In the arrangement shown, the single racks have shelves 4 x 18 feet, and in the double racks the shelves are 9 x 18 feet. Thus the latter style will accommodate patterns from four to nine feet in length.

At the end of the pattern storage room, next to the foundry, a space is left clear for the care and storage of patterns too large for placing upon the shelves. It will, of course, be understood that in every shop special arrangements must be made for the care of patterns peculiar to the kind of work done, and that the arrangement here given is only such as may be useful in a general way, and that it is subject to whatever modification may be necessary to suit individual conditions. For instance, if there are many heavy patterns like lathe beds, planer beds, or engine beds, etc., it will be necessary to provide a larger space for them, and also to arrange for readily lifting and moving them. A convenient method is to suspend an I-beam overhead, and upon this to run a trolley with a chain or rope hoist, by means of which the patterns can be picked up and moved wherever they are wanted. These may be put up with branches and switches, so as to cover any desired space.

If these large patterns are placed entirely upon the floor they will occupy too much valuable space. They may be arranged in this manner: One bed pattern may lie upon strips not less than an inch thick laid on the floor. Over this pattern are placed two or more trestles, high enough to clear it. Upon these a second pattern may be placed. Over this place still higher trestles, and upon them support a third pattern, and so on. The advantage of this method is that the patterns may be always kept in good condition and "out-of-wind," while if, as is often done, strips are laid upon one pattern, and another pattern supported upon it, there is a strong probability that it will be marred and injured, or warped out of shape.

Various forms of racks, both self-supporting and attached to the building, have been devised. The common form used to be that of supporting the shelves by a series of posts placed four to eight feet apart, and spiking to these

horizontal strips, upon which the boards or planks forming the shelves were placed. Frequently a strip three or four inches high was placed around the shelves to prevent the patterns from falling off. This made a receptacle for dust and dirt which was not only disagreeable but difficult to get rid of. In this form of racks the numerous uprights obscured a good deal of light, and were very much in the way of conveniently handling patterns.

Considering these conditions, the best arrangement of pattern racks seems to be of the forms shown in Fig. 113 and Fig. 114. The form shown in Fig.

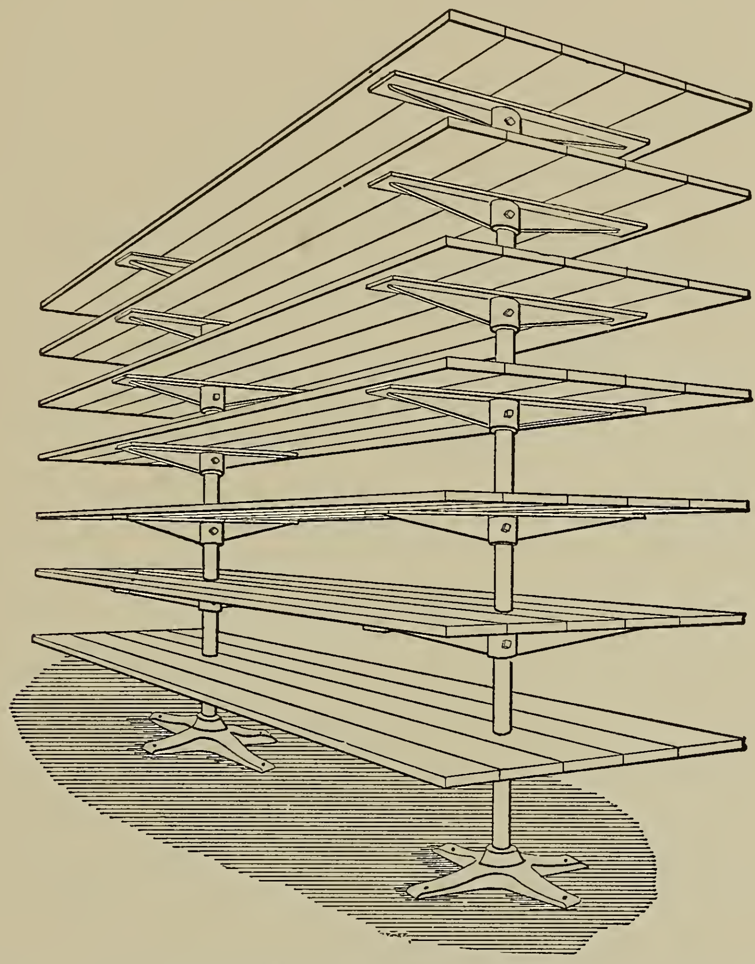


Fig. 113. — Pattern Storage Rack with Metal Frame with Wood Shelves.

113 is composed of two heavy cast iron bases, into which are screwed pieces of 3-inch wrought iron pipe. Upon these are fitted cross supports of cast iron with rough-cored holes. They are held at any desired height by two set screws in each support. Upon these supports the shelves are built, their thickness being according to the weights of patterns to be stored. For ordinary patterns the shelves should be of $1\frac{1}{4}$-inch planks, and the distance between supports not over eight feet. Where heavy patterns are to be placed on the shelves the planks should be $1\frac{1}{2}$ inches thick, and the distance between supports reduced to about six feet. In this case set screws should not be depended upon to hold the cross supports in place. Pieces of wrought iron

pipe, large enough to easily slip over the upright supporting pipes, and cut the exact length necessary, should be used, by first placing one over the pipe and resting on the cast iron base. Then put on the cross support, then another piece of pipe, and so on to the top. The planks are fastened with heavy wood screws passing up through the cross supports. The bases should be fastened to the floor with lag screws.

If inconvenient to construct these tracks with iron supports as just described, they may be constructed entirely of wood. If this is to be done the uprights are fastened to the floor and also to the overhead timbers by nailing, or, still better, by iron knees and wood screws, so as to be held firmly in their proper position, as shown in Fig. 114. To these uprights are spiked cross

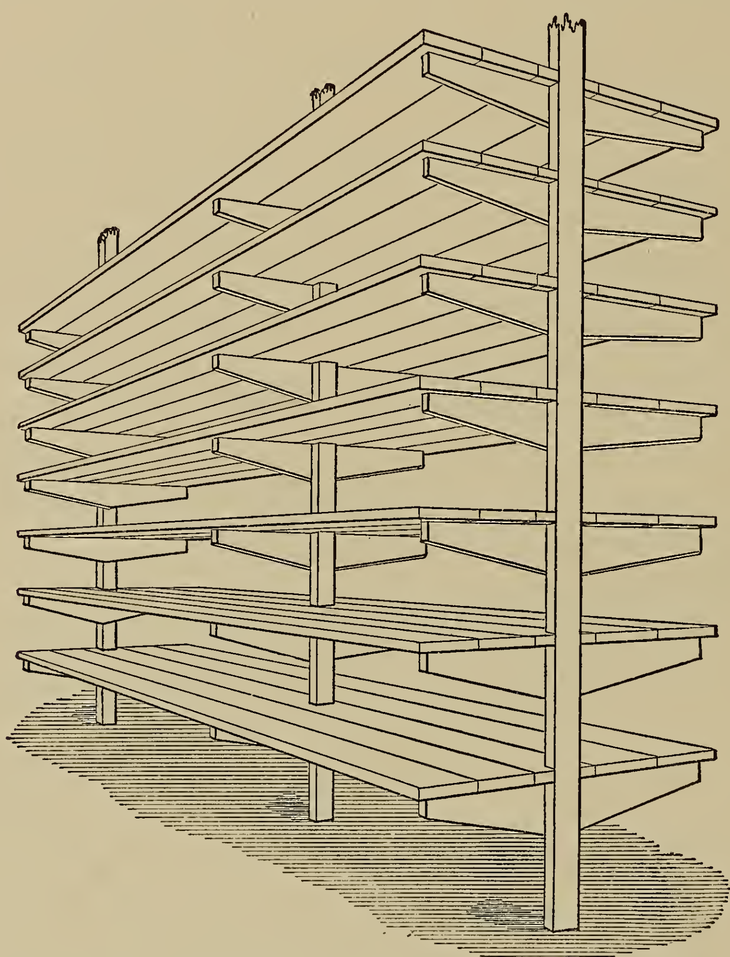


FIG. 114. — Pattern Storage Rack, all Wood Construction.

pieces or supports of the form shown, and upon these are laid plank shelves as described for the shelves when iron supports are used. If the patterns are very heavy, the cross supports may be let into recesses in the uprights, and fastened with through and through bolts. The proper distance between supports will be the same as with the iron construction of supports. For ordinary and usual conditions the vertical distances will be about as follows: From the floor to the top of the first shelf, two feet; from the top of the first

shelf to the top of the second, twenty-two inches; to the next, eighteen inches; to the next, sixteen inches; to the next, fourteen inches; and to the top, twelve inches. Of course these shelves may be continued higher up than this, but on account of the difficulty of access the above arrangement would seem to be quite high enough.

Several light step ladders should be provided for conveniently reaching the patterns on the upper shelves. Obviously, the heavier patterns will be placed on the lower shelves. Large gears, pulleys, balance wheels, etc., may be set on edge, in racks similar to those used for holding rolls of belting, but are somewhat more liable to become warped than if they are laid down flat on the shelves that are true and level.

In the case of the double-width shelves, as called for in the plan, Fig. 109, there should be two upright pieces of wrought iron pipe to carry the cross supports, the latter being made of appropriate form, and having cored in it two holes, four feet apart, from center to center. A similar modification should be made in the wooden construction. For racks of 18 feet in length there should be three supports, the outer ones placed thirty inches from the ends, and the third one in the center. This will provide for three wrought iron pipe supports in a rack 4 feet by 18 feet, and for six supports to a rack that is 9 feet by 18 feet.

One of the greatest conveniences of this system of shelves for storing patterns is the fact that they are free of access on all sides, with absolutely no obstruction whatever, either to light or the handling of patterns, while their appearance is much better than any of the older forms. Shelves should not be built against walls unless they are comparatively narrow, as the light will be so much obstructed as to prevent seeing the patterns at the back of the shelves. If built as herein described and located between the windows as shown, they offer little obstruction to the light, which passes comparatively free from side to side of the building.

CHAPTER XXI

THE IRON FOUNDRY

Special conditions. Some early history of the foundry. Modern foundry appliances. Plan of the foundry. Tram car tracks. The transportation of materials. Charging cars. Elevator to cupolas. Blast apparatus. Electric motors. Bench work. Pneumatic hoists. Their capacity. The air compressor. Molding machines. Sand sifters and mixers. Molding pits. The cupolas. Foreman's office and storeroom. The heating apparatus. The shipping room. The pickling beds. The pickling vat. The cleaning room. The core room. The core oven. The flask room. The wash room. The water-closets. The lockers.

The equipment of the iron foundry necessarily differs in many respects from that of the other departments heretofore considered, as to its product, its work, and the necessary arrangements for carrying it on. These requirements, while they have changed much since the earlier plants for this work were established, have not perhaps undergone so great a change in a general way as have those of the machine shop. The early plants were, of course, very crude and primitive affairs, and iron was often melted in crucibles somewhat as brass is melted now. Most of the work done was of the plainest kind and little attention was paid to symmetrical or artistic effect.

Early history shows that the making of iron castings was one of the oldest mechanical industries of the country. In the year 1643 John Winthrop arrived in this country from England, bringing with him the necessary number of skilled workmen for this purpose, and built a small iron foundry in Lynn, Mass., and the fact that the first casting which was made was "a small iron pot holding about a quart" shows the modest capacity of the foundry. The casting is said to have been made "from native ore."

Little progress seems to have been made for a considerable time in enlarging the original scope of the work from its early beginnings, so far as records of the facts are known. In 1735 an iron foundry was established in the little town of Carver, Mass., and a second one was built in the year 1760, wherein the historic "Massachusetts Teakettle" was cast.

Another foundry was built in 1793, and was burned down in 1841. The proprietors of this foundry were Bowers & Pratt. A relative of the latter partner established a foundry in Wenham, Mass., and his son, at a later date,

built a foundry in Watertown, Mass., which was the original of the now well-known foundry of the firm of Walker & Pratt, for whom the author had the privilege of making the first drawings of their heating apparatus to be reproduced by the original photo-engraving process invented by Moss, and operated by the Moss Photo-Engraving Company, on Park Place, New York City. Following the gradual development of the iron-founding business from the early times is very interesting, but too long a story for the available space of these pages.

In these later years the addition of the traveling crane, the pneumatic hoist, the application of electricity, the iron flasks, the sand blast system for cleaning castings, and similar improvements have changed many of the older methods, and rendered the work less laborious and the output much larger. At the same time the quality of the work, both in its practical and in its artistic features, has been greatly improved and more economically produced.

The foundry floor has been particularly described in Chapter XI on floors, in the Part First on Machine Shop Construction, to which the reader is referred for detailed information on this point.

Fig. 115 shows the general arrangement of the foundry and its equipment. The central portion is provided with a traveling crane, and under this and the two jib cranes shown the heavy molding and casting are done. Tram car tracks, located as shown, bring in any stock and material, such as sand, flasks, pig iron, coal, etc., as may be necessary, upon cars specially constructed to adapt them to each class of load to be carried. Turntables are provided at the intersection of the tracks, in preference to curves and switches, as they occupy much less room, do not require any more time to operate, and the cost is nearly the same, for equipment offering like facilities. The special construction of these tracks and their accessories will be particularly described in a future chapter on shop transportation.

In bringing pig iron, coal, etc., to the cupolas the material is brought on the cars to the turntable scale in front of the elevator, and there it is weighed, then run upon the elevator, raised to the charging floor and the cars run upon the branch tracks, and thence to the cupolas, as shown in Fig. 116. The charging cars are specially constructed for this purpose, and are substantially the same as used by the Vilter Manufacturing Company in their foundry in Milwaukee, Wis.

A rear elevation of one of these cars is shown in Fig. 117, and a side elevation in Fig. 118. The frame consists of two similar iron castings for sides, held together by cast iron cross rails bolted to them, as shown. The car body *A* is composed of 2-inch planks, lined with sheet iron, and supported by wrought iron, forged straps *B*, *B*, of U-shaped form, at the back and front, and by cast iron angle supports *C*, *C*, near the center. Upon these

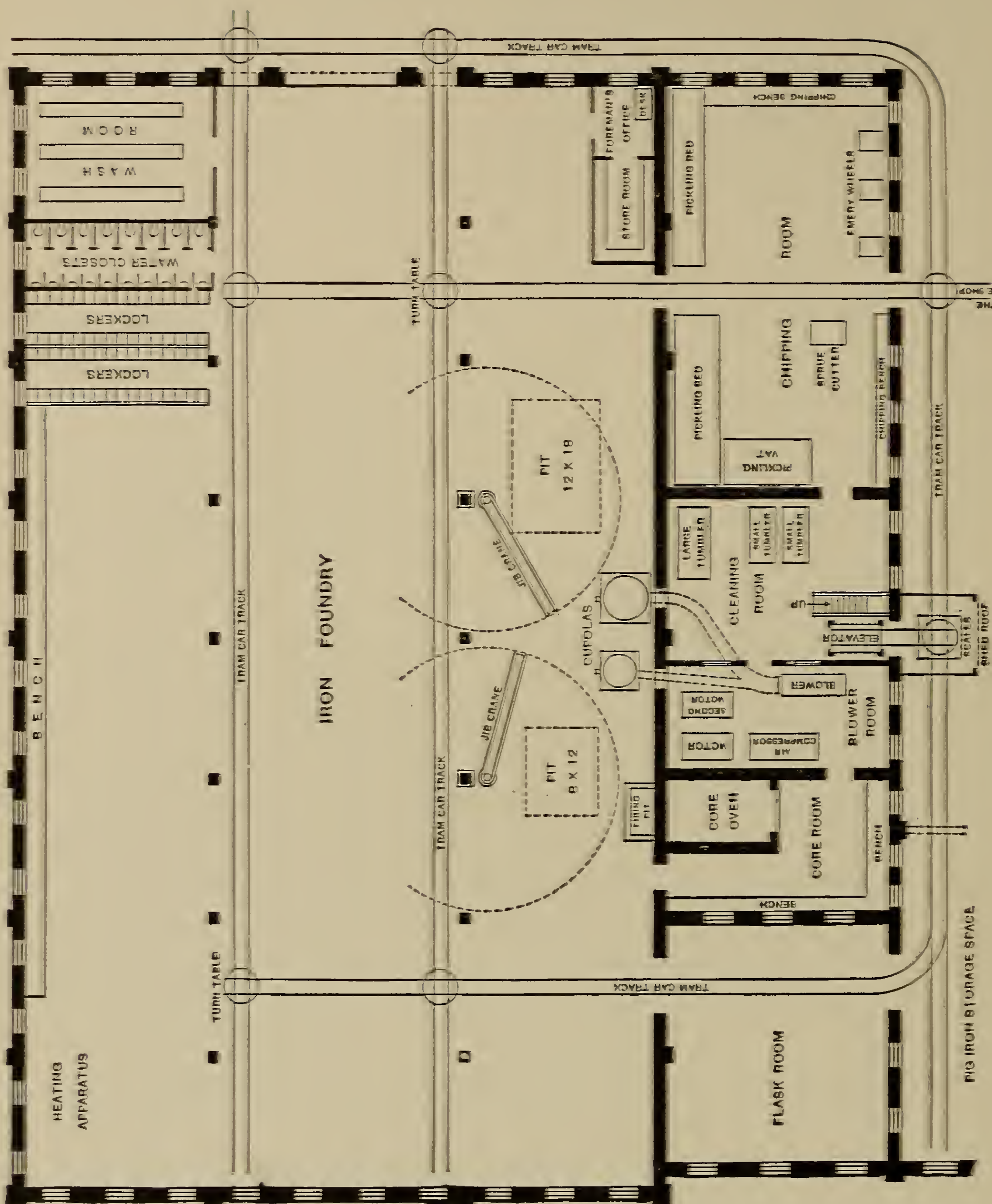


FIG. 115. — Plan of Foundry, showing General Arrangement and Equipment.

supports are formed downwardly-projecting lugs, by means of which the car body is pivoted by the rod *D* to the frame, as shown in Fig. 118. The greater part of the load is placed back of this pivot, thus holding the car body in a horizontal position. Pivoted to the rear end of the car body is a rack *E*, engaging a pinion on a horizontal shaft *F*, which has fixed upon its front end

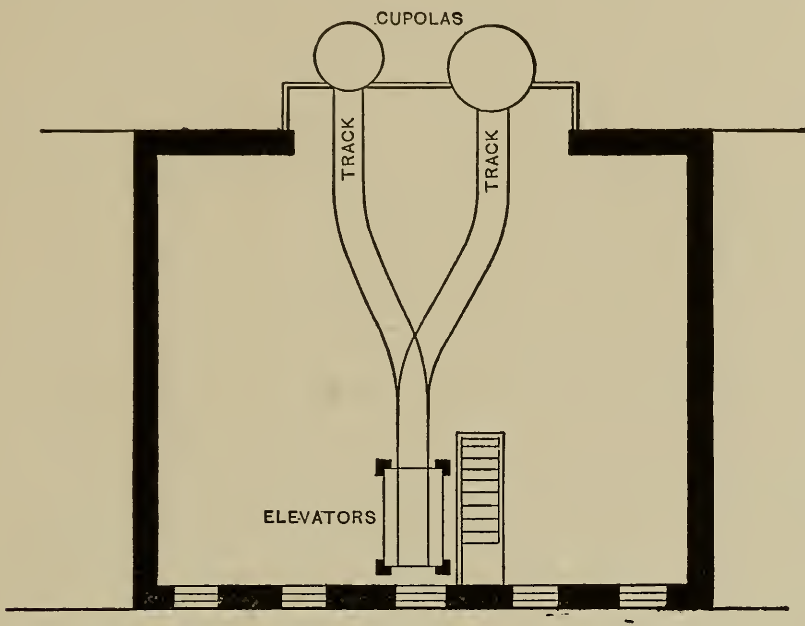


Fig. 116. — Branch Tracks for Cars to run from Elevator to Cupola.

the spur gear *G*, engaging the spur pinion *H* on the shaft *J*, which is squared on the front end for the application of a crank, by means of which the rear end of the car body may be raised and the contents of the car dumped. The dumping position is shown by dotted lines in Fig. 118. The car is of very simple construction; the gear and rack teeth are cast, the wheels and gears bored, and the hubs faced, but not turned on the outside. Several of these cars should be provided, so that there may be no waiting on the charging floor for either pig iron, scrap iron, coal, or coke, during the progress of a heat, when time is valuable.

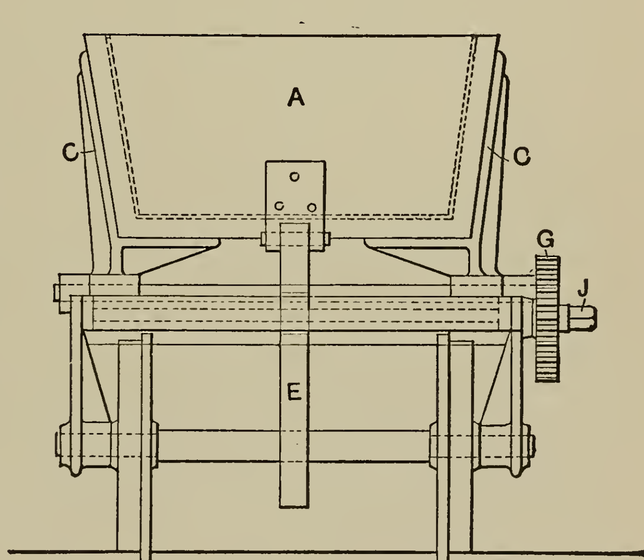


Fig. 117. — Rear Elevation of Charging Car.

In Fig. 115 the location of the cupolas is shown, and also that of the blower and the blast pipes leading from the latter to the cupolas. A motor is also located in the blower room, which is used to furnish power to run the blower, and also the eleva-

tor, the tumbling barrels, and the machines in the chipping room. It may be preferred to have two motors, one to be used only for running the blower, and run for a few hours only when a heat is on, and the other constantly, for driving the machinery above mentioned. These motors may be located side by side in the blower room, as shown. The blower may be placed on the floor, but it is often advisable to locate it overhead, out of the way of dirt and dust and more nearly on a level with the tuyeres of the cupolas, so that some of the curves in the blast pipes may be avoided, as this is a very important matter when the amount of air pressure is to be compared to the power necessary to generate it, as in this class of blowers it is considerably more than is generally supposed, even by good mechanics.

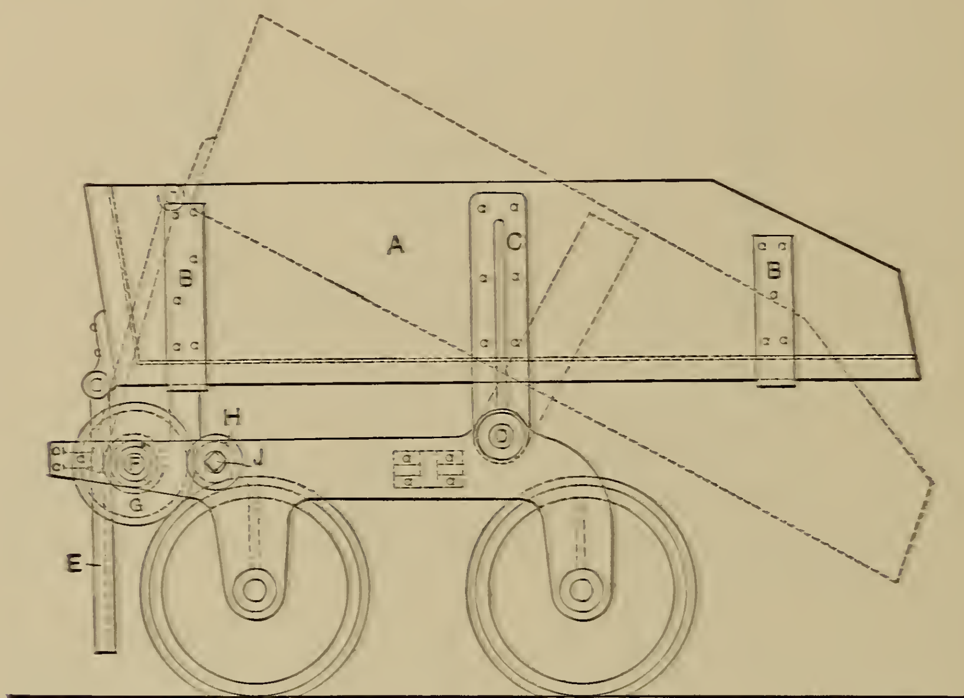


FIG. 118. — Side Elevation of Charging Car.

The motor, or one of them, may furnish power to operate the traveling crane by the old system of a square shaft running the length of the building beside it and so providing power at any point in its travel; but this method is a rather clumsy way to transmit power, and it is a much better system to have the traveling crane carry its own motor, the current being supplied to it by flexible, pendant cables near the wall and out of the way. These should be placed on the side of the building opposite the cupolas, where there will be no obstruction to them and where they will be away from the excessive heat.

The general molding floor of the foundry should have its work so arranged that the spaces outside of the supporting columns will be devoted to the lighter floor work and the bench work, where crane service is not needed. A bench

is provided along one side as far as the heating apparatus (which occupies the outer front corner), for bench, or snap flask work. Here it will be found very convenient to use the compressed air hoists for floor work, as it will be in other parts of the plant, as the hoists may be suspended overhead and used not only for drawing the deeper patterns but for turning over flasks, for it is now a demonstrated fact that in compressed air we have a very useful, convenient, and efficient power, which may be utilized in the foundry, perhaps to as good or better advantage than in any other department of the modern manufacturing plant. Its uses are many, and the conveniences with which it may be carried to any part of the floor for individual use, or for the lifting of quite heavy loads, renders it almost indispensable in the routine work of the foundry. The economy of its use may be readily appreciated when it is remembered that an air compressor provided with a cylinder 6 inches in diameter, and a storage tank 3 feet in diameter and 5 feet long, compressing air to 80 pounds per square inch, will furnish ample supply for a dozen hoists lifting 400 pounds or more each.

In drawing patterns, turning small flasks, setting large cores, and similar work, these hoists may be suspended in any desired location, the rubber hose attached bringing a supply of compressed air, easily controlled by a simple valve. These hoists may be suspended from a trolley traveling on an overhead beam, so located as to be convenient to the work. Of course, larger hoists may be used when necessary, and they are quite as effective and economical. Roughly speaking, a hoist with a 3-inch piston should lift 450 pounds; with a 4-inch piston, 800 pounds; with a 6-inch piston, 1,850 pounds; and with an 8-inch piston, 3,300 pounds. A supply of compressed air is very useful in the chipping room, where chipping tools may be very efficiently operated with it, and by its use one man may thereby do the work of at least two, and usually more.

An air compressor may be located in the blower room, as indicated in Fig. 115, and operated by the motor situated there. A cylinder 12 inches in diameter will be ample for the ordinary uses of the foundry floor and for operating such tools as are necessary in the chipping room. It will require a tank about 4 feet in diameter and 8 to 10 feet in length. This may be situated over the air compressor so as not to occupy the floor space. Such a tank should, of course, be constructed on the same lines and of like materials as a steam boiler of similar size, and to withstand the same pressure per square inch. It should be remembered that under ordinary circumstances, if the air compressor is constructed on the plan of the boiler-feed pump, with a steam cylinder and an air cylinder, with one piston common to both, the proportions will be nearly these, viz.: steam cylinder, 6 x 8 inches, and air cylinder 10 x 8 inches. And also, that 90 pounds steam pressure will give

about 65 pounds air pressure, with a piston velocity of 300 feet per minute. These figures are given as nearly correct and easily remembered.

A large variety of molding machines are in the market, many of which are admirably designed to turn out a large quantity of work in a day, and to save much of the manual labor usually necessary. They are, of course, employed on comparatively plain work where the tamping of the sand may be easily done by forcing down upon it a comparatively flat surface. They are usually employed upon the lighter kinds of work.

Molding machines are also made for molding the teeth of gear wheels of large dimensions, as well as large segments, and by their use much time is saved and the cost of large and expensive patterns for the gear teeth is avoided. There are also molding machines for pulleys, which are valuable as a part of the foundry equipment, and with a proper supply of rims and spiders this work is much simplified and the costs reduced.

These machines must be selected and provided in accordance with the particular class of work to be done, as their utility will depend almost entirely upon this matter.

Sand sifters and sand mixers are now made so as to be mounted upon a tram car and are driven by a small electric motor attached to them, the machine being thus rendered complete in itself, and may be easily moved to any part of the foundry desired and, when not in use, run out of the way. They will be found very convenient on nearly all classes of work, and may supersede the usual hand riddles almost entirely, saving much of the molder's time and producing better castings, as more sifted sand is likely to be used if the molder is not obliged to sift it by hand. Besides, being sifted close at hand, it is not so liable to contain foreign matter as if it is sifted at one point and carried to different parts of the foundry where it may be needed.

The deep molding pits are located as shown by dotted lines in Fig. 115, one 8 x 12 feet, and the other 12 x 18 feet. These may be of any required depth, but more usually the smaller one would be about 5 feet and the larger one about 8 feet. All these dimensions should, of course, be made according to the character, size, and the weight of the larger castings to be made. The walls and floors of the pits should be constructed according to the directions given in the chapter on Shop Floor Construction, in Part First of the work. These pits will be found very useful in molding large pieces wherein a very deep nowel flask would be required, and which would necessarily raise them several feet higher on the floor than would be the case where a pit is made use of. Such pieces, which may not be cast on their side, and weighing, say, over 4 tons, will usually be found fit subjects for pit molding.

It will be noticed that the cupolas have been located within the space of the foundry proper. This, of course, will occupy considerable room on the

foundry floor. They are so placed in many foundries, this being a more desirable location in several respects. In this case they come nearer to the cranes, which are supported from the main columns, and afford a convenient means of transferring a ladle of melted iron from the cupola front to the cars, and thence by the track to any point in the foundry, or from the cranes over to the traveling crane and thence to any part of the central space of the floor. The cupolas may be located in the cleaning room and the blower room space, and thereby save about 140 square feet of molding floor space. In this case the cranes will be placed closer to the wall, but yet with sufficient reach to pass ladles of melted iron to the car track, or to the traveling crane.

If this disposition is made the location of the tumbling barrels will need to be changed, placing one at the front of the room. If it is found necessary, the motors and the air compressor may be placed on the charging floor, where there is ample room for them. Even the blower may be located there, for the purpose of affording more space on the first floor, a partition dividing them from the charging floor proper. The stairs also may be placed at right angles to their position as shown, for the purpose of affording any specially desired location for the first-floor equipment. In case the cupolas are placed in the cleaning room and blower room space, it may be advisable to run a car track immediately in front of them, connecting at each end with the transverse tracks by the usual turntables, and by which means ladles of melted iron may be transferred to the central space under the traveling crane by taking the route either to the right or left, as may be the shorter distance. However, many will prefer the jib crane for this service, as being quick, efficient, and safe.

In the back corner of the main part of the foundry proper is the foreman's office, and adjoining it is a storeroom for the various small articles, tools, etc., necessary for almost daily issue, and which the foreman of a foundry of this size will probably find necessary to have under his personal control, although it will be advisable to have an employee in the office who is conversant with these matters, and to act as a bookkeeper, in order that the foreman's time may not be too much taken up with these matters of routine details.

In the front corner, on the outer side, is located the heating apparatus, which has been previously described in the general chapter on Heating, in Part First on Shop Construction. If preferred, it might as well be located in the corner next to the flask room. This would be convenient if more bench room was required for snap flask work.

The chipping room is provided with the usual benches, having a sufficient number of vises on them to accommodate the work requiring hand chipping. Sprues are cut off in the sprue cutter where this can be done by such a machine. The three emery wheels will do much of the small finishing on the castings,

while the pneumatic chipping tools will do very much of the work on the heavy castings.

Pickling beds are provided for, as shown on the plan, Fig. 119. These

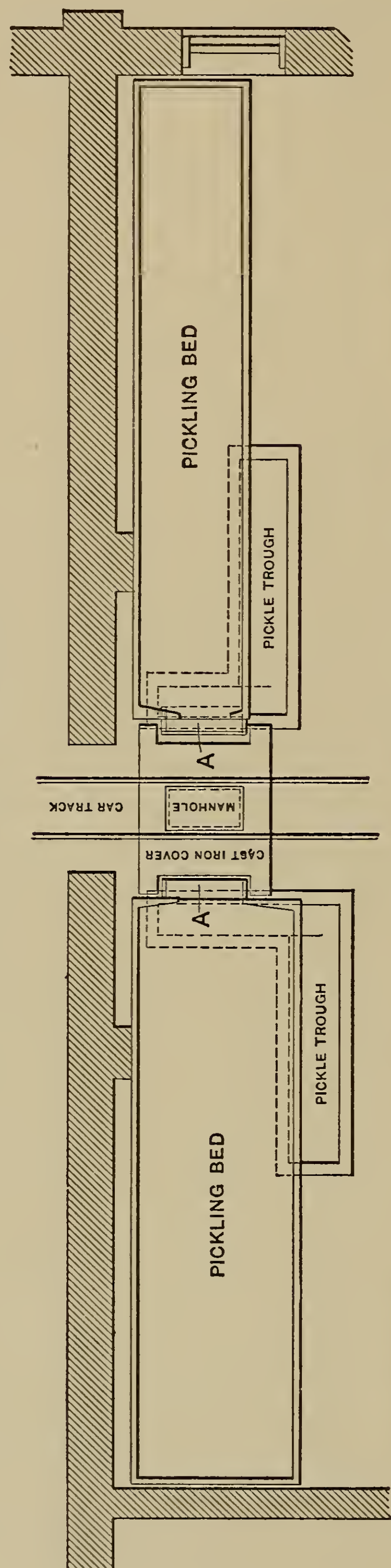


Fig. 119 — Plan of Pickling Beds.

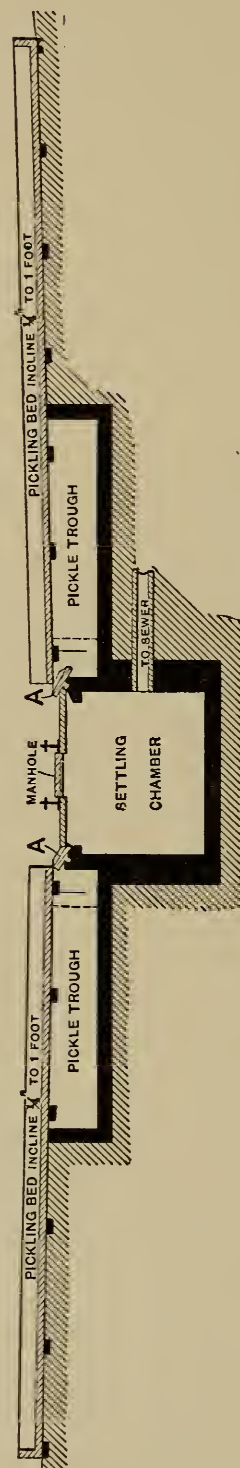


Fig. 120. — Vertical Section through Pickling Beds.

should be so constructed that the pickling solution may drain off into a receptacle where it may be saved and used again, while the water used in washing

the castings after pickling, and the burned sand and scale coming from the castings, will go into another receptacle, where the sand and scale may be retained and the water flow into the sewer.

A very efficient method of accomplishing these results is in use in the new foundry of the Brown & Sharpe Manufacturing Company, Providence, R. I., and with some necessary modification it is shown on an enlarged scale in the plan Fig. 119, and in vertical, longitudinal section in Fig. 120. The pickling beds are built of 2-inch plank, supported on timbers 4 x 6 inches, placed not over 4 feet centers, and have at both sides and at the upper end a plank 8 inches high. This bed is lined with sheet lead of sufficient thickness to not be easily cut through by laying castings upon it.

Very heavy castings may rest upon pieces of board laid upon the lead for its protection. The lead should not be thinner than an eighth of an inch for ordinary uses. The pickle bed inclines toward the drainage system a quarter of an inch to the foot. The pickling solution or wash water dripping from the castings upon the pickling bed flows to the lower end, and upon a narrow tilting table *A*, which directs its course as may be desired. In the position shown on the right of the drawing it will run the pickling solution into a transverse conduit, from which it flows into the pickle trough, where it may be dipped up to put on other castings. When the castings are sufficiently pickled and it is desired to wash them, the hose is brought into use and the tilting table *A* is placed in the position shown on the left in Fig. 120, and the wash water flows into the settling chamber. Considerably above the bottom of this chamber a drainage pipe leads to the sewer. All sand or scale which passes down from the washing process drops to the bottom of the settling chamber, from whence it is cleared out as often as necessary through the manhole between the car tracks, as shown. A cast iron plate covers the settling chamber, supporting the car tracks passing over it, as well as the manhole cover.

Near the pickling beds is located the pickling vat, in which small castings may be immersed until sufficiently pickled, then placed upon the pickling beds to drain and be washed. This is constructed of planks and lined with lead, the same as the pickling beds. Concrete construction may be used if desired.

An overhead trolley and hoist should be placed over the pickling beds, for removing castings from the cars and transferring them to the bed on the right or left, as may be desired, and back to the car when they are finally washed. Another similar overhead trolley should be placed in the center of the room for lifting castings to and from the floor and cars. These two trolley beams may be connected if desired, and run as one system.

The hoists may be operated by compressed air, in the same manner as those in the foundry proper. If the sand blast process is to be used for cleaning

castings it will be necessary to enclose a space of sufficient size in which to operate it, in order to prevent the disagreeable dust created by its use, provided the high velocity usually used is to be arranged for. There is, however, a sand blast apparatus made in Germany which uses a very coarse sand at a comparatively low velocity, which appears to be a success, and does not require to be operated in a close room.

The core room is provided with benches on two sides, and the usual form of core oven, which is fired from a pit formed in the floor of the foundry proper, by which arrangement the entire height from the core room floor is utilized for the cars upon which the cores are arranged and run into the oven from the floor level. The core oven may have its entire front closed with sheet iron doors, running up out of the way; and upon the inner sides of the oven walls a series of supporting bars, permitting cars to run in, one above the other, their front ends being suspended on overhead trolley beams when they are drawn out. By this means the upper portions of the core oven may be better utilized and smaller lots of cores may be run in and baked at a time; or, the oven may be divided by a vertical partition and one side used for a large car, filling the entire space, and the other side arranged with shelf-like cars or racks, for small lots of cores. Separate doors should be provided to close each section so as not to expose one section to cold air when cores are to be put in or taken out of the other. By this arrangement much more work may be baked than if the whole front is to be opened at once. The doors may swing upon hinges if there is a lack of height for lifting doors, although the latter, properly balanced, form a very convenient arrangement, and not in the way when the doors are opened.

The flask room requires no special arrangement or equipment beyond the car track and its cars for carrying flasks to and from the molding floor, unless a very considerable number of the flasks are of small and medium sizes, when they might be conveniently stored upon a gallery floor, which might extend nearly around the room. Flasks could be quickly and conveniently passed to and from this gallery by means of a pneumatic hoist. By this means the storage capacity of the room could be increased at least 50 per cent, perhaps more. The alcove arrangement of flasks is very convenient for the purpose of easily reaching any size flasks needed. Thus, groups of two piles of flasks, backs together, may be piled up to any convenient height, with a passage between these groups, flasks of similar size forming each pile when possible. A little study of this arrangement will save much unnecessary labor in handling the flasks when wanted.

The wash room is located in one of the outer corners of the foundry proper, as shown in Fig. 115, and has adjoining it the water-closets, and next to these the lockers for the use of the employees. The water-closets should

be so arranged as to be flushed automatically, and a continual supply of running water be provided for the urinals. The washing sinks are of cast iron and arranged with an individual supply of water from a pipe running along above them. One of these sinks is shown in perspective in Fig. 121. By

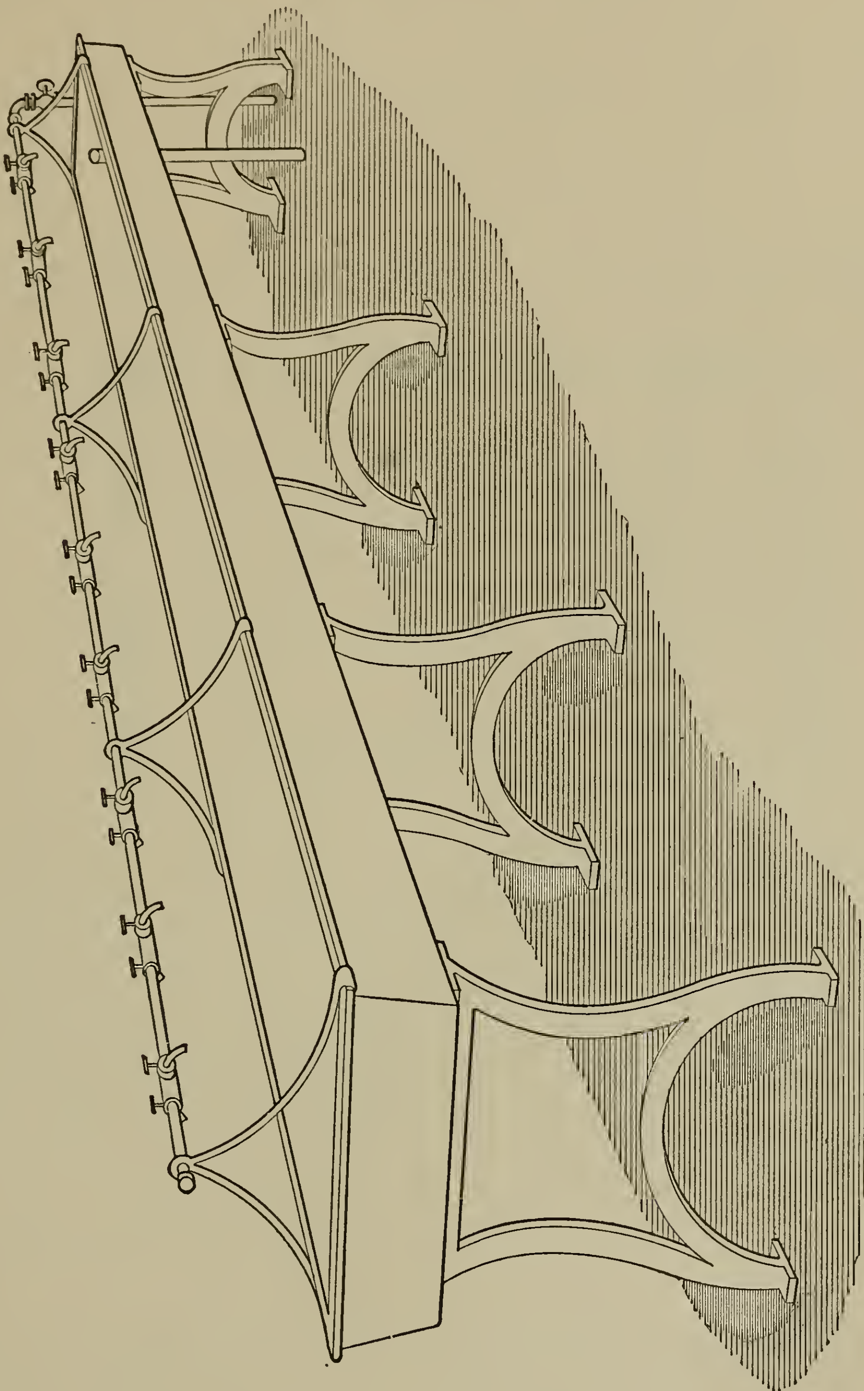


Fig. 121. — Cast iron Washing Sinks, with Individual Supply of Water.

this method of water supply each man may have clean water, and still the expense of separate wash bowls is avoided. The plentiful supply of fresh water is nearly always appreciated by the men, although the author once knew of a shop in which a similar arrangement for their cleanliness was made and the men refused to use it, preferring to wash in the common pool of not over-clean water in which all the rest of the force did the same. It has been said

that "there is no accounting for taste," and this may be a case in point. Certain it is that the well-meant efforts of shop owners and managers are not always appreciated by the employees.

The lockers are of expanded metal, and are of the usual dimensions for such use, that is, 12 inches deep, 18 inches wide, and 72 inches high. The width might be decreased to 15 inches and still provide ample room. They are placed in rows facing each other, with the two rows in the center back to back, for economy of space. In the plan just described it will be noticed that the lockers, the wash room and the water-closets are each separated from the other. In some respects this is not as convenient as it will be to have the lockers arranged in the wash room. Such a plan is shown in Fig. 122. The

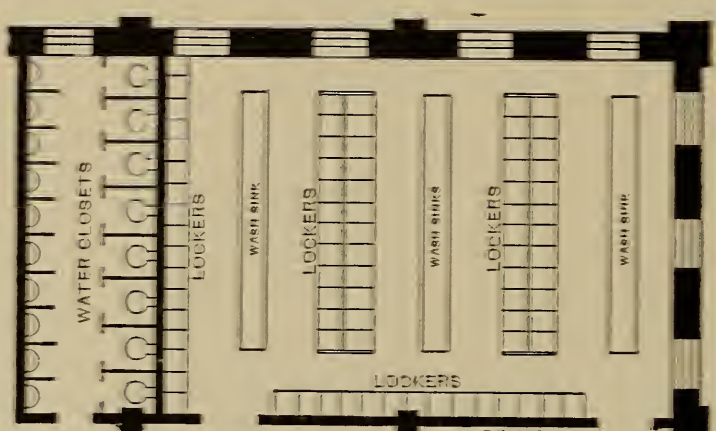


FIG. 122. — Plan, showing Arrangement of Wash Room.

amount of space and the expense necessary are about the same in either case, but the latter arrangement will probably be preferred by the employees generally, as being more convenient to have their lockers near where they are to wash up, and it will cause less confusion in running back and forth from one to the other, at a time when every one is in a hurry to wash, dress, and get out in the shortest possible time, and the capacity of the wash room is usually taxed to its fullest extent.

CHAPTER XXII

THE FORGE SHOP

Its present restricted sphere. Improved facilities. Case-hardening and tempering. The addition of machine tools to its equipment. The proper location of the forge shop. Its special construction. Transportation of stock and material. Coal and bar stock storage. Foreman's office. Portable scale. Forge fires. The down-draft system. Construction of forges. The blower. Blast pipes. Arrangement of blast apparatus. Steam hammers. Drop presses. Special heating furnaces. Annealing and case-hardening furnace. Detailed description. Cutting-off machine. Power hack saws. The cold saw. Heavy shear. Heavy turret lathe. The forge lathe. Work benches. Steam supply. Compressed air. Electric motor drive. Jib crane. Overhead trolleys. Pneumatic hoists. Bar stock storage rack. Shop rack for bar stock. The wash room. The water-closets. The lockers. Compactness of the design.

It is undoubtedly true that since the very general introduction of turret lathes, forming lathes, and the large variety of similar machines now in use in almost every machine shop making any pretense to modern equipment and up-to-date methods of doing work, the forge shop has lost considerable of its importance as one of the indispensable departments upon which the machinist of former times very largely depended for much of his material for the better classes of work. The introduction of steel castings, malleable iron castings, and other similar materials, superseding in many cases the old-time forgings, has also been an important factor in the same direction, and has decreased the cost of materials of complicated form, and at the same time provided the machinist with materials which have admirably answered the purpose as to strength, and lessened the amount of machining necessary for their practical use.

And yet, while the forge shop may have decreased in the matter of importance in the making of forgings, there will always remain the demand of the machine shop for a certain amount of strictly machine forgings of iron and steel which cannot be met by any other material. Many great and important advances have been made in forging by use of improved hammers, by dies in connection with them, and by the process of drop forging, yet there is a large demand for forgings requiring the services of the skilled machine forger with his expertness in hand forging, as well as his technical knowledge

of handling steel of various qualities, his expert knowledge of how to produce forgings of complicated and intricate forms, and the thousand and one conditions and requirements demanded in successfully bringing out such work, correct in form and structure, and within a reasonable cost.

In the matter of case-hardening and tempering the forge shop department has increased materially, as there has never been a time in the past when hardened and ground steel work has been as much used in the better qualities of machine construction as at present; and case-hardening has reached such an extent that it is rare to find nuts, cap screws, and the like on any well-constructed machine that are not protected from injury by this valuable process.

While the actual forging work of the forge shop has decreased its scope, it has in a general way much increased in volume, since it is now customary to add to its equipment several machine tools, such as cutting-off machines, forge lathes, heavy turret lathes, cold saws, power hack saws, and other similar machines for roughing out work, which in many instances can be much more economically done by these methods than by confining the operations to forging under the hammer. In this case the appropriate machines for these purposes are included in the equipment of the forge shop and located as will be presently described, and as shown on the plan in Fig. 123.

The foundry floor, the engine foundation, and many of the foundations for machines in the machine shop, should be kept as free from jar, and from shocks sufficiently strong to disturb the ground by vibrations, as possible. For this reason the forge shop is placed as far from these buildings as may be convenient; therefore, in the rear corner of the plant, and opposite the rear end of the machine shop. The spur track from the railroad, which supplies shipping facilities and brings to the plant the raw materials necessary for its use, runs across the rear end of the group of buildings, in the rear of the machine shop and storehouse. It continues in a curve around the rear corner and up the side to the foundry gate, rising, as it goes to a height sufficient for conveniently dumping coal, coke, molding sand, etc., into the storage sheds located along that side, the first of which is shown at the left of the forge shop in Fig. 123. The curve of the railroad track cuts off somewhat of this rear corner of the building space and therefore the forge shop is located far enough from the rear line to accommodate it, and the space so left is utilized for a one-story building containing a space for the forge coal, another for bar stock storage, and the wash room and water-closets.

The forge shop is, like the other buildings of the plant, built of brick, with steel roof construction, the roof trusses being supported in the center by steel columns. It is lighted, not only from the side windows, but from those in the monitor roof, the sashes of which are hung on pivots and controlled by cords reaching nearly to the floor, by which they may be operated when neces-

sary for ventilation. The general plan of the forge shop is clearly shown in Fig. 123, which also shows the contiguous buildings and their positions in reference to the forge shop, as well as the location of the railroad track, and

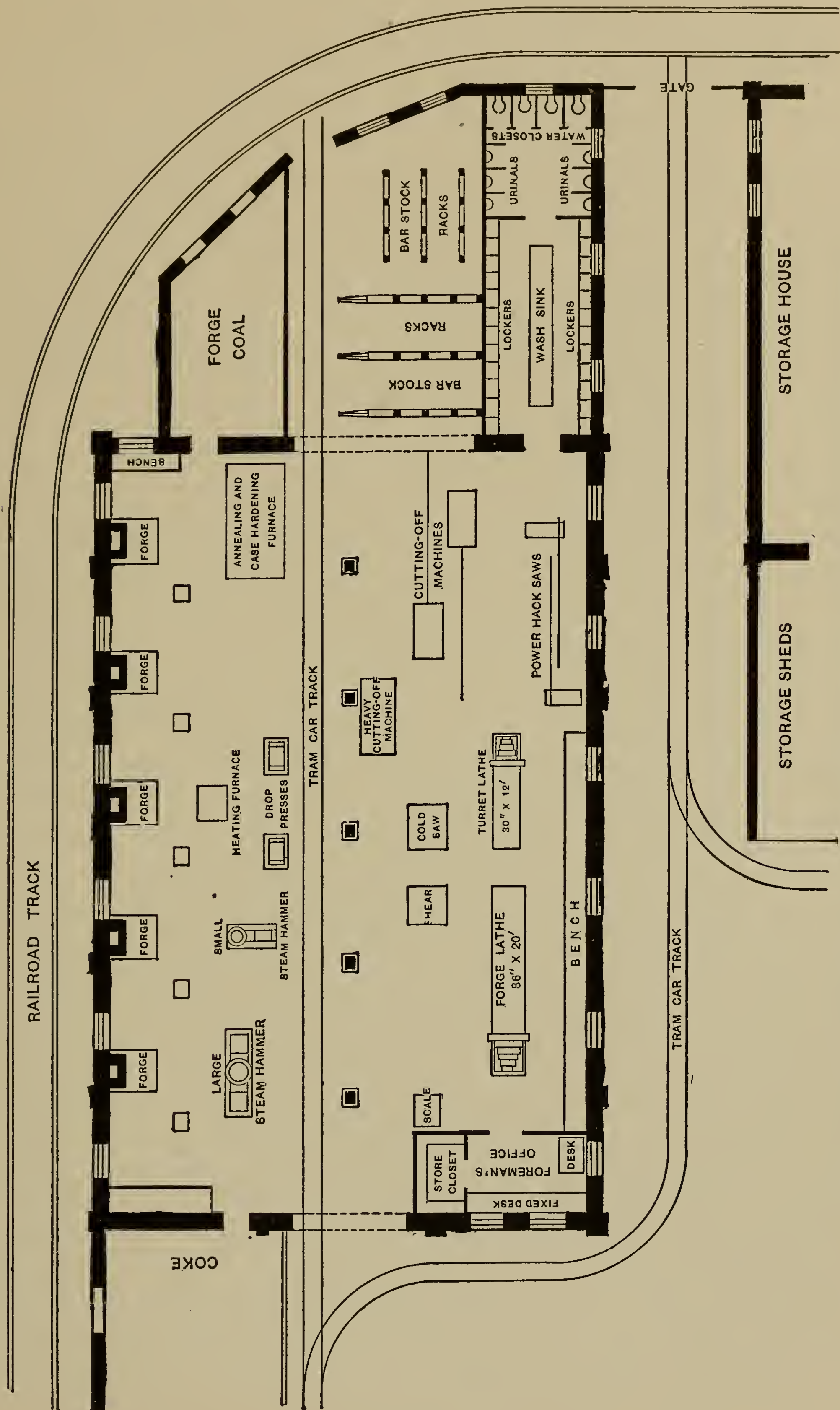


Fig. 123. — General Plan of Forge Shop, showing Proper Arrangement of the Machine Tools, etc.

the tram car tracks connecting this department with the railroad tracks in the rear and the other departments toward the front of the plant.

For convenience in bringing in stock and taking out finished work the tram car tracks run nearly midway through the forge shop, as shown, and are connected by their branches with the foundry, the machine shop, storage sheds, and practically all departments of the plant, as well as at three points with the railroad track, two of these being shown on the plan.

The foreman's office is located in the front corner of the shop, and has connected with it the usual foreman's store closet for such minor supplies as are more conveniently kept there than in the general storeroom near the offices. A fixed desk furnishes a convenient place for spreading out drawings, and a private desk is provided for the foreman's personal use. Outside of the office is a forge shop scale for weighing stock and forgings. This scale should be mounted on wheels so that it can be readily moved to any part of the shop where it may be needed.

Along the outer wall of the shop are located five regular forge fires having chimney flues built into the wall for their accommodation. These latter will not be necessary if the system of down-draft forges is used. This form of forge has several good qualities, not the least of which is that it offers less obstruction in handling large pieces of work, as it may be conveniently placed at a distance from the wall if desired, and will furnish quite as good ventilating facilities in clearing the shop of coal gas as those connected with separate chimneys. The draft may be increased or decreased at the will of the operator, particularly in the case of forges manufactured by the Buffalo Forge Company, in which a hinged and adjustable hood may be closed down over a fresh fire and raised for the handling of the work to be heated, as may be desired. If these down-draft forges are used it will be necessary to provide an exhaust fan with the proper connecting pipes for carrying off the smoke and gases, which may be delivered to one chimney, thus avoiding the expense of building the other four. Such an arrangement is very clean and wholesome for the workmen, when compared with the method shown, but considerably more expensive in its first cost, as well as requiring extra power to operate it.

The forges shown on the plan should be of such construction that the tuyeres may be readily attached and detached when necessary, for cleaning or for repairs. They should have such a form of bottom valve or gate as to readily discharge the clinkers or slag that may find its way down to it. These forges are usually constructed of cast iron and supported upon four legs, so as to give convenient access beneath them for cleaning, attaching the blast pipe, repairing, etc. Each should have, cast with it, or attached to it, two narrow troughs, running the length of its front, or shortest side, for holding coal and water. Many excellent ones are in the market and can be purchased more

economically than they can be built on the premises. The blast pipe should be arranged to slide on and off easily, in case it is necessary to disconnect it for cleaning or repairs, and it should be provided with a regulating valve or gate, fitting as nearly air-tight as may be, and operated by a lever conveniently located within the reach of the operator. These forges are usually made of rectangular form, but large fires are often made upon a circular forge, whose sides extend to the floor. They need not necessarily be provided with the water and coal troughs as mentioned above, as they are usually used for heating work for the steam hammers, drop presses, and similar large work, rather than for tempering, tool forging, or small work of this class.

The blast for these forges, for the heating furnace, for the drop presses, and for the case-hardening and annealing furnace, is furnished by a fan blower designed for a pressure necessary for forge work, and having an outlet of six inches in diameter, equivalent to a No. 3 Sturtevant steel pressure blower, which is admirably adapted for this purpose. It should be located over the bench near the forges, at the front end of the shop, so that there may be no unnecessary turns or bends in the pipe leading to the forges. These pipes should be placed along the walls near the floor, but never beneath it. In one shop the author saw blast pipes, composed of vitrified drain tiles, the joints made with Portland cement, and laid less than a foot beneath the surface of a dirt floor of the forge shop, and at one point passing directly under a bolt heading machine.

As might have been expected, the jar of the shop floor broke up the pipes and destroyed their usefulness. The blast pipes should be constructed of heavy galvanized iron, well fitted and fastened, and as nearly air-tight as may be. They should be easy of access, for the possible connection of additional pipes and for convenience of making repairs, which will have to be made sooner or later. They might be placed six or seven feet high, and along the walls, but this position will necessitate about thirty feet of additional pipe, increasing the friction of the air and consequently the power required, with no especially compensating gains other than getting the pipes up out of the way somewhat.

Some of the more important rules for setting up and connecting forge blowers may be here given. Place the blower as near as possible to the forges. Make the pipe connections as direct as possible. If bends or elbows are absolutely necessary, make the curves of large radius, and with no abrupt angles; the inside radius of an elbow should not be less than twice the diameter of the pipe. Have the aggregate areas of all the outlet pipes at least equal to the delivery pipe at the blower. If the pipes must carry the air over one hundred feet, speed up the blower proportionately above the figures given in the manufacturers' catalogue. In any event, the blower should be run at

such a speed as will give four to five ounces pressure at the tuyeres, not less than four ounces at the forge farthest from the blower.

The blower is driven from a line shaft running the length of the shop near its center. In front of the first fire is located a large steam hammer of the arched pattern, and capable of handling work up to 10 inches in diameter. At the next fire is a smaller, single-column steam hammer of about half the capacity. The necessity of providing the larger hammer will be a matter to be decided by the size of the largest forgings to be made. For instance, if only a few forgings which come up to its capacity are to be made, it will be more economical to purchase them of some large forge shop than to provide a large hammer that may be idle much of the time. The smaller hammer should be provided for even moderate-sized work, for any plant of modern pretensions.

Next to the small hammer two drop presses are located, with a special heating furnace for use in connection with them. These drops should carry hammers weighing from 150 to 600 pounds, according to the work which they are to do.

The heating furnace need not be over 30 inches square outside, built with a cast iron shell lined with fire bricks, supported on four cast iron legs, and provided with a vertical sliding, balanced door in front. The heating chamber will be about 20 inches square and from 10 to 12 inches high. A blast pipe leads up to it, and a smoke pipe from its rear side leads to the nearest chimney. Such a furnace will heat work for drop forging much more economically and satisfactorily than the usual open forge fire. They may be purchased at a very moderate cost.

The forge fires not occupied with steam hammer work will be used for ordinary hand forging, tool forging, tool dressing, tempering, and similar work. Where much tempering of special work is necessary, that is, when a large number of pieces of the regular product of the plant is to be so treated, special arrangements as to heating furnaces, dipping baths, etc., must be provided, and in many cases special automatic heating and hardening furnaces are employed. Obviously, the great variety of this class of work precludes a detailed description in this chapter.

Near the end wall, at the rear, is located an annealing and case-hardening furnace of ample capacity. As this will be built on the premises, and as information in reference to its requirements and its construction may not be readily available, drawings have been made showing the details of its construction and giving all necessary dimensions.

While this is for a furnace of quite large capacity for a machine shop plant, a smaller one may be readily constructed on proportionate dimensions, with good and practical results. If it is to be of say one half these dimensions, or one

fourth the capacity, the lower heating ducts will be single instead of double, and it will be preferable to build it with a cast iron casing inclosing all four sides, forming the door frames, and the separate pieces being bolted together at the corners, instead of having the brickwork held together by binders and rods as shown in the drawings.

The construction is clearly shown in Figs. 124, 125, and 126, being respectively a front, side, and a rear elevation. Fig. 127 is a cross-section through the fire box *A*, showing the bridge wall *B*, the form of the covering arch *F*, and the position of the blast pipe *G*. Fig. 128 is a longitudinal section showing the fire box *A*, heating chamber *C*, heating ducts *D*, *D*, and sections of the front and rear doors. Fig. 129 is a cross-section through the heating chamber *C*, the heating ducts *D*, *D*, dividing wall *M*, and the main door *N*. The foundation should be laid deep enough to support the weight of the furnace and its charge, and will be quite similar to that provided for boiler settings. The shaded portions indicate fire bricks, the balance being ordinary, hard, red bricks. The grate bars are of any convenient pattern, but must

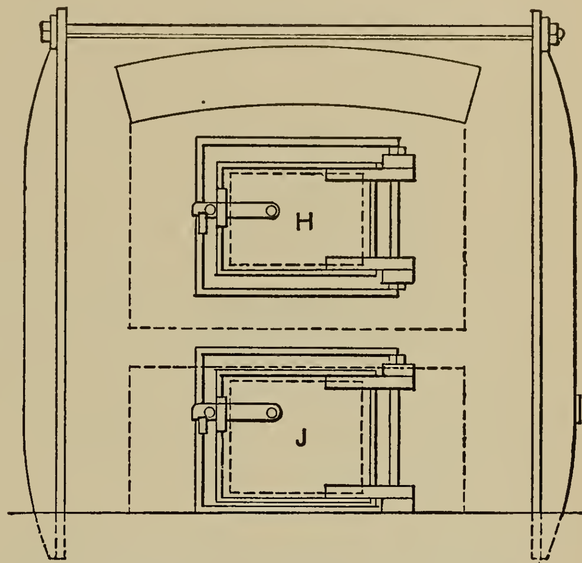


FIG. 124. — Front Elevation of Annealing and Case-hardening Furnace

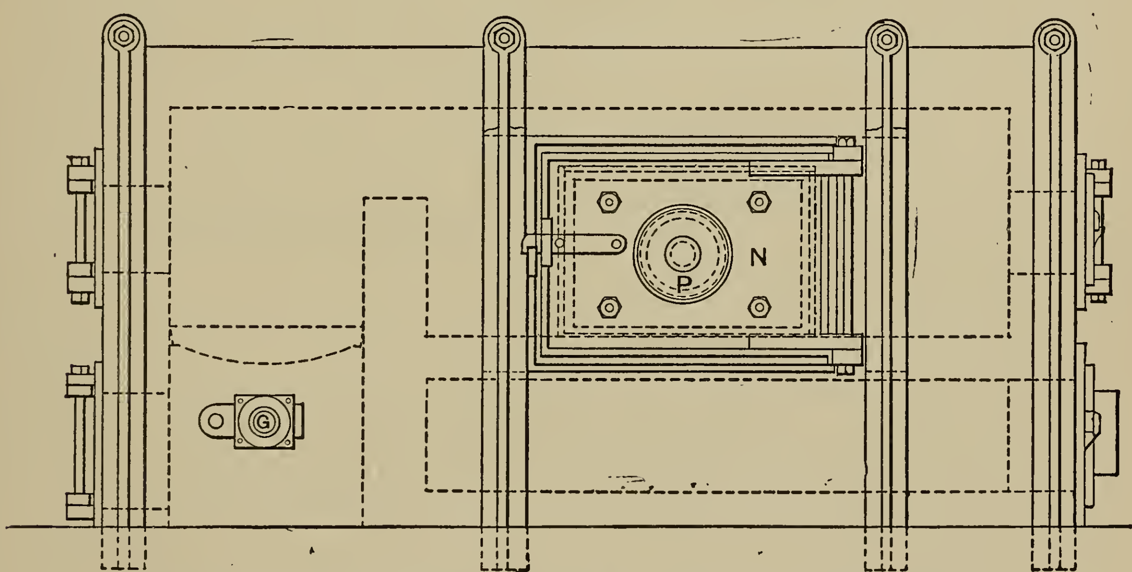


FIG. 125. — Side Elevation of Annealing and Case-hardening Furnace.

have ample air spaces so as not to impede the air blast delivered through the blast pipe *G*. The top arch is of fire brick and is carried all the way through both front and back walls, for convenience in making repairs upon it.

The floor of the heating chamber is composed of fire brick tiles 5 inches thick, 9 inches wide, and 24 inches long, their outer ends supported by the inwardly projecting side walls, and their inner ends by the dividing wall *M*. They are laid about an inch apart so as to permit the gases and smoke to pass down between them to the heating ducts *D*, *D*, and out through the smoke pipe attached to the rear door *L*. The frame and door of the fire box are from the same pattern as the rear door *K*, while the frame of the ash pit door *J*, and the smoke door *L*, are from the same pattern. The doors are different, of course, as the door *L* must be provided with a circular sleeve to which the smoke pipe is attached, its other end connecting with the nearest chimney.

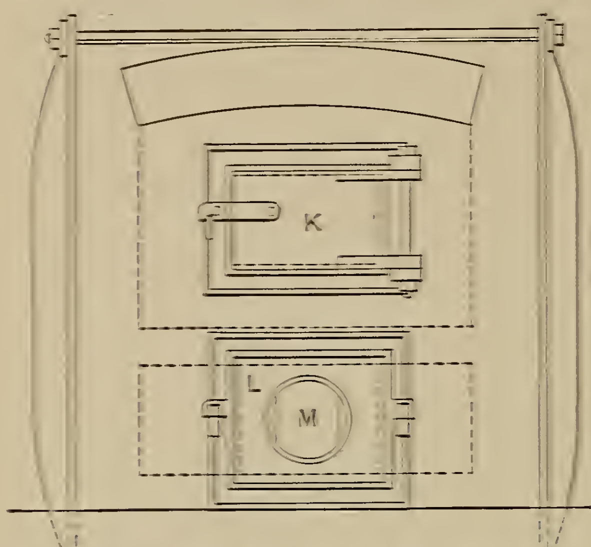


Fig. 126. — Rear Elevation of Annealing and Case-hardening Furnace.

The main door *N*, through which the annealing boxes are introduced and removed, is of special construction and fitted with a fire-brick lining, perforated by a circular opening or "peek hole," and held in place by four bolts (as shown in Fig. 125), which pass through iron straps on the inside of the fire brick lining. The stopper *P* is of tubular form and has an inwardly-projecting flange at its inner end for the purpose of holding the lining, which is composed of fire clay packed in as solidly as possible while it is slightly wet. This stopper may be removed at any time to obtain a view of the interior of the heating chamber and its contents during a heat, as all the doors are tightly closed and the cracks luted with fire clay as soon as the fire is well under way, one charge of coal being usually sufficient for the heat after the furnace has been heated up.

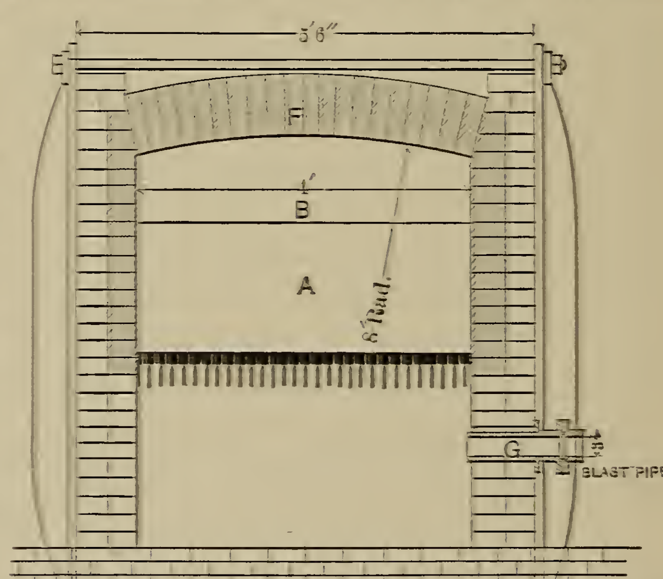


Fig. 127. — Section through Fire Box, etc., of Annealing and Case-hardening Furnace.

The blast pipe furnishing the blast for the forges will also supply this furnace, the pressure required being the same, and will be connected to the fixture *G* located in the wall of the ash pit for that purpose.

Such a furnace as has just been described will, if properly built, and with occasional repairs to the fire brick lining, last many years. The author knows of one which was built twenty years ago that is in serviceable condition at the present time.

On the opposite side of the central columns is located the group of machines for roughing out stock, the first being a heavy cutting-off machine capable of taking in stock up to six inches in diameter and cutting it off to any required length. In this machine there should be two tools fed automatically, and the machine should be provided with a convenient speed-changing device whereby the surface cutting speed may be maintained constant at all diameters, as this latter feature will materially increase the output of the machine.

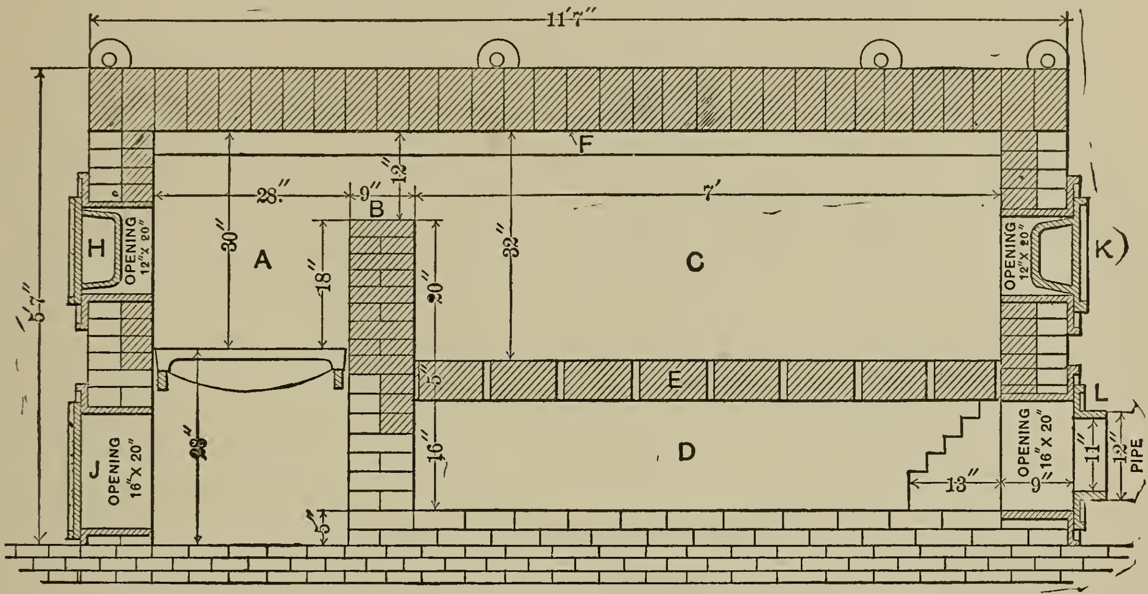


FIG. 128. — Longitudinal Section of Annealing and Case-hardening Furnace.

Next to this machine are two cutting-off machines of a capacity for 4-inch stock and arranged similarly to the larger machine. They are so placed as to be conveniently operated by one man.

Next to these machines are two power hack saws, provided for cutting off square and flat stock. These should carry from 12 to 15 inch saws, and while apparently slow-working machines are capable of cutting off a large quantity of stock in proportion to the labor cost of attendance.

Located near the large cutting-off machine is the cold saw, which will serve for stock or forgings beyond the capacity of the cutting-off machine or the power hack saws, and will often save much valuable time in finishing up a forging. The saws in these machines are from 12 to 40 inches in diameter, the former size cutting off stock up to $3\frac{1}{2}$ inches in diameter, and the latter handling 13-inch stock. For this case the saw should be 20 inches in diameter, and capable of cutting off $7\frac{1}{2}$-inch stock. There are many of these saws in the market and apparently not very much choice between them, all conditions being considered.

The shear, located next to the cold saw, is not generally as much used as before the power hack saw came into notice, yet in certain classes of rough work it is very useful and operates quickly. It should be able to cut off round stock up to one inch, square stock to the same size, and flat stock to half inch by two.

In the heavy turret lathe much work may be roughed out from the bar and sent to the machine shop in a more satisfactory condition than if it had been forged, and at the same time it will do the work more economically. It should take in stock up to 3 inches in diameter and be provided with a heavy, open, hexagonal turret, bored so as to allow the stock to pass entirely through it if necessary. If should also be provided with heavy roughing tools somewhat similar to box tools, as well as a heavy cutting-off slide adjustably supported on the bed.

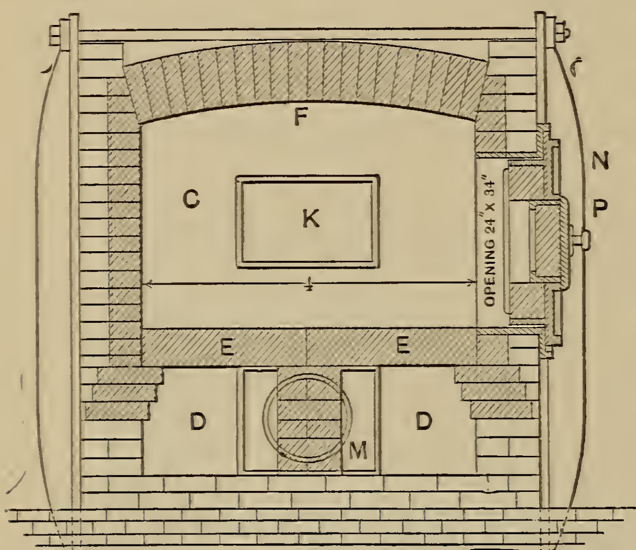


FIG. 129 — Section through Heating Chamber of Annealing and Case-hardening Furnace.

The forge lathe, located next to the turret lathe, will be useful in rough-turning spindles and similar heavy work, and doing it much cheaper than forging the work down to close dimensions. It should be built for cuts of 6 or 8 to the inch, and a cutting speed from 100 feet per minute and slower.

A short work bench and vise is provided at each end of the line of forges for the convenience of the blacksmiths, and a much longer one on the opposite side for the men running the machine tools, which should have three vises upon it.

A supply of steam will be needed for the steam hammers, and may be brought from the power house in a conduit, the pipes being properly protected by a non-conducting covering to prevent, as far as possible, the loss of heat. But these hammers may be operated by compressed air, which will not be subjected to such loss. And as power will be required to run the line shafting driving the various machines, it may be more economical to bring in a current of electricity with which to drive one or more motors, by which the line shafting may be driven and from which a small air compressor may be operated, thus bringing the power within the building and under the control of the foreman in charge of it. This plan would seem more advisable than the other. If an air compressor is used it may be located between the shear and the scale, and the reservoir connected with it placed directly overhead.

If an electric motor is used to drive the line shaft it will be convenient to place it overhead and near the center of the shaft, on a platform erected for the purpose, rather than to place it on the floor level, where it will be subjected to dirt and accidental injury.

A jib crane may be erected to serve the large steam hammer and an overhead trolley for the smaller one, the latter being the more economical of the two, and will be found nearly as convenient for comparatively light weights. The I-beams carrying the trolley and hoist should run from a point nearly over the center of the forge to a point close to the left side of the hammer, as seen on the plan.

Pneumatic hoists may be conveniently used not only on this trolley but in a similar way at the forge lathe and over some of the other machines for handling heavy bars. They work quickly, are easily handled, and when necessary may be readily moved from place to place.

The space for bar stock is located conveniently to the railroad track and the tram car track, and contains two racks for bar stock, the larger one for full length bars of iron and machine steel, and the smaller one for ordinary cast steel and tool steel bars. The larger of these racks is shown in perspective in Fig. 130. This is constructed of oak timbers formed into a rectangular frame, strongly bolted together and resting on good foundations capable of supporting the heavy weights of stock likely to be placed in the racks. Three of these frames are erected, six or seven feet apart and braced by cross braces as shown. The timbers should be 6 inches square and provided with iron supports for the bar stock. These should be spaced further apart at the bottom than at the top, the bottom space being, say, fifteen inches, and the top space eight inches, center to center of cross bars. These supports should be flat, say $\frac{5}{8}$ by $1\frac{1}{2}$ inch for the upper three; for the next two, $\frac{3}{4}$ by $1\frac{3}{4}$; and the two lower ones, 1 inch by 2. It may be preferred to make the three or four lower supports of $1\frac{3}{8}$-inch round steel, upon which are placed pieces of $1\frac{1}{2}$-inch gas pipe, turning freely, and so facilitating the running in and out of heavy bars. As seen in the engraving, the right-hand end of the frames may be securely bolted to the brick walls, and the cross braces on this end be omitted. At the opposite, or front end of the frames, the sill timber projects from the front of the frame about three feet, and upon this are erected heavy cast iron supports, of the form shown, which will be found very convenient for holding heavy bars, as they are open at the front, and bars may be readily lifted from the tram cars to them. Experience has shown this to be a very convenient, useful, and substantial form of bar stock rack. In place of wooden timbers cast iron supports may be used, but the cost will be much greater and the results not enough better to compensate for the added expense.

The smaller rack is built on the same plan, and may be constructed with

or without the cast iron racks in front of it. It should have substantial cross braces between its frames, and also be securely braced from the brick wall.

For a shop rack the form shown in Fig. 131 will be found very convenient.

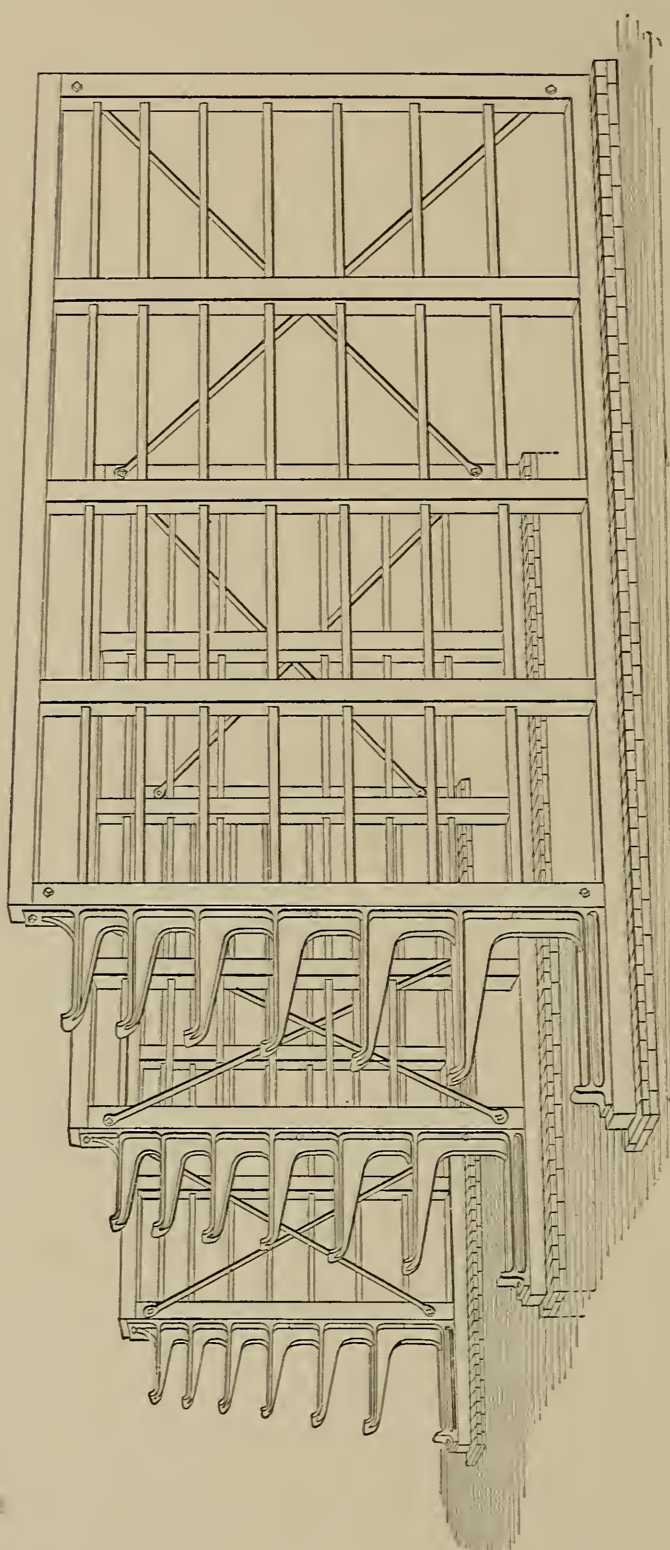


Fig. 130. — Rack for Bar Stock, for Storing Long Bars of Iron and Steel.

The A-shaped supports are of cast iron, securely braced by cross braces bolted on as shown. The base of the supports might be made relatively narrower than shown in the drawing without endangering their stability. Such a rack

may be made of any number of supports and placed at any desired intervals apart that the work may require. Once we have the pattern, we may make as many castings as we choose and arrange them to suit any existing conditions. Usually they should not be over 5 feet high, unless rather small and light stock is to be placed on the upper supports. The lower projecting supports may be about 10 inches long and the top ones about 7 inches.

The wash room is located in one of the rear corners, and in connection with the water-closets, which open out of it. A single wash sink of similar construction to the one illustrated and described in the article on foundry equipment is provided, and the individual lockers for the use of the men, and built of expanded metal, are arranged on both sides of the room in the usual

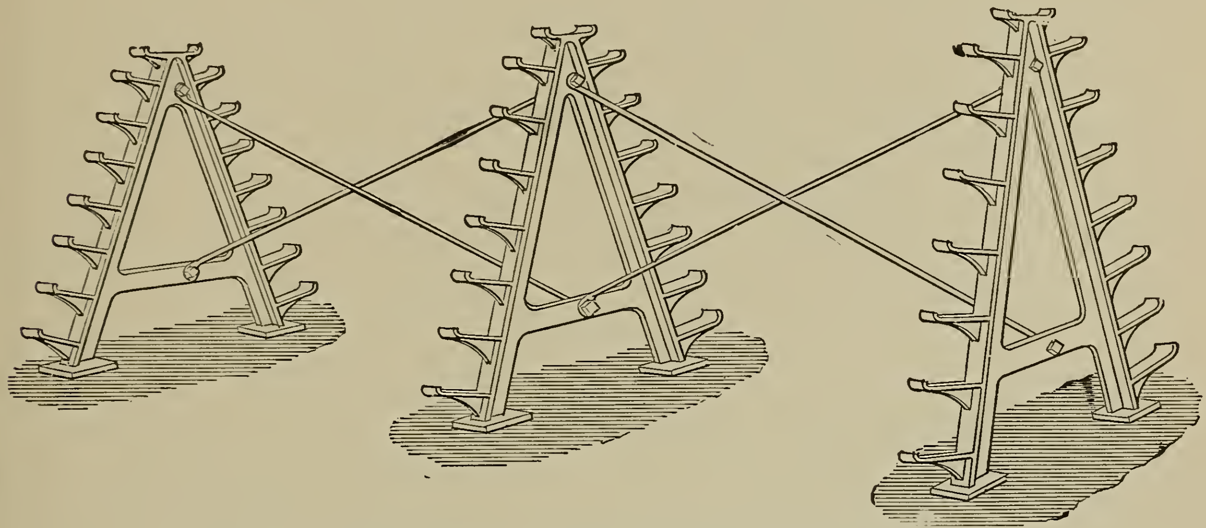


FIG. 131. — Small Rack for Ordinary Cast Steel and Tool Steel Bars.

manner. In the water-closets six urinals and four closet seats are provided, the latter protected by double-hinged swinging doors, and the former separated by dividing partitions two feet wide. Both should be provided with an ample supply of water for automatically flushing them. The windows lighting the wash room and water-closets are placed high enough in the wall so as not to interfere with the lockers or the urinals.

By the plans herein given all of the requirements of the operatives are placed conveniently within the building, so that whether for stock, fuel, or any reasonable cause, there is no necessity of leaving the building, as it is a well-known fact that men working near artificial heat, as do those at forges, are very sensitive to both heat and cold out of doors, and that to make proper provision for their health, comfort, and convenience, while at their work, is not only proper and commendable in itself, but always conducive to their efficiency as workmen.

CHAPTER XXIII

SHOP TRANSPORTATION EQUIPMENT

Its importance in the modern machine shop. Careful planning necessary. Continuous progress of work through the different departments. What may be classed as transportation facilities. Traveling cranes. Overhead trolleys. Shop tracks. Yard car crane. Shop trucks. Portable crane. Yard tracks and cars. Cast iron track. Requirements of a floor track. An economical system of shop tracks and cars. Overcoming wheel friction on curves. Forms of wheels and track. Dimensions of track. Switches. Track timbers. Yard tracks. Track for shop floors. The turntable. Shop cars. Construction and dimensions. Various forms of shop cars. With removable stakes. With removable boxes. With racks for special work. With trays for special work. Dump car for coal, sand, etc. Double car, two cars and a special platform. Varying dimensions of cars. Number of cars necessary.

The question of the transportation of stock and material from the point of its receipt from outside sources to the various departments where it is to begin its regular transit from the raw material to the finished product, of transferring this material from one department to another during its progress through the shops, and of its final transit from the department where it is finished to the storehouse, for safe keeping or for shipping to customers, is an important matter. For if closely followed through all its various stages, and the expenses accurately kept, as to the capital involved in the appliances necessary, the proper maintenance of these facilities in good working condition, and the labor necessary for their successful operation, it would appear to be a far larger item of expense in the general account than would usually be supposed from a superficial consideration of the question.

This is a matter upon which careful planning is needed in all its bearings, as any saving in this respect, while still rendering good service, is an actual saving, and, unlike the reduction of the cost in building a machine for the market, is not liable to effect a deterioration of the real quality or value of the product. This does not mean that the service can, or should be, made inefficient in order to avoid expense, but rather that it should be well planned, well administered, prompt and efficient in every way, yet without a useless appliance or an unnecessary man employed in it. For instance, the progress of the work through the different departments should be so arranged that, as far as possible,

it may be really progressive from the raw material to the finished product, with as little retrograde movement as may be. In this way a considerable percentage of the work of transporting materials and stock in progress may be saved, rendering a less extensive equipment of cars, trucks, etc., necessary, as well as a smaller force of employees for handling them.

In arranging the different departments of the plant here shown due consideration was given to this matter and they were carefully planned with this end in view, as will be more fully pointed out in the chapters on Machine Shop Management which will succeed this part of the work.

In the list of appliances that may be classed as transportation facilities, we may mention traveling cranes, overhead trolleys, shop cars on tracks, cars on yard tracks, hand trucks, and small tool conveyors. Of these, the traveling cranes may be those propelled by a shaft running the entire distance of their travel, by those carrying an electric motor for their propulsion, and those of small capacity worked by hand, with a chain reaching down near the floor. Again, as to lifting power, they are operated by the shaft above mentioned, by a motor, or by chain blocks with the usual differential chain wheels or other similar device.

Overhead trolleys running on I-beams may have a small motor mounted upon them furnishing the power for their propulsion as well as for their lifting power. Frequently those of moderate capacity are pulled along by hand, and the loads lifted by chain blocks operated by hand. These trolley tracks are so constructed that they can be put up in straight lines, curves, switches, crossings, etc., which render them very convenient for light work, and they occupy but little room overhead, and none at all on the floor. In some cases, however, existing overhead obstacles such as shafting, belting, countershafts, etc., preclude the use of either the overhead trolley or the traveling crane; in others the weights are not sufficient to demand the expense of a traveling crane; in still other locations several traveling cranes would be required to cover the space to be operated in. Then there are other situations in which lack of height prevents the use of the overhead trolley system.

Shop tracks for the accommodation of cars of the usual size, say 34 inches wide and 5 feet long, will be of the same gage as the yard tracks, or about 20 inches, so that the shop cars or heavier and larger yard cars may be used on the whole system. These cars may be propelled by small electric motors in the form of an electric locomotive, which is simply a car fitted with two motors operated by a storage battery, but more often they are pushed about by hand, particularly when loaded with less than 2 tons weight.

A balance crane may be erected on a car for yard or shop use, and may by this arrangement be capable of picking up and carrying a load up to a ton or two. It is very useful in locations where power for loading is not available.

Four-wheeled shop trucks, with the front axle pivoted and handled by a tongue, should have their wheels so constructed and located as to properly run upon the shop tracks as well as upon the floors.

The Franklin portable crane is simply a small jib crane on wheels, which may be moved about the shop as easily as a hand truck. Its capacity is from one and a half to three tons. It readily lifts and holds the load at any point so that it can be wheeled to any desired location. It is now made also with a gasoline motor, or an electric motor run by a storage battery for both propulsion by traction wheels and the power for lifting — making a very complete and portable power crane for many ordinary shop purposes. It will be found a very convenient and useful addition to the shop equipment.

The traveling cranes provided for in the various departments do not seem to need any detailed description. There are many excellent ones in the market and they should be selected with a view to the special requirements of each case.

In considering a system of tracks for yards, and the system for the construction of cars for use upon these tracks, the Hunt system is probably the best and most complete of anything in the market, particularly when heavy work is to be undertaken. However, for moderate loads a more economical method of construction may be adopted, and one that may be built in the shops without a great outlay for patterns or special tools.

Metallic ties are no doubt the ideal method for laying track on the ground when steel rolled track is used. Yet a cast iron track, properly constructed and properly supported, will be found very practical for every-day service in a plant of such a character as the one under consideration. Again, where track is to be laid on upper floors it would not seem advisable to use the heavy plate track made of cast iron on account of its considerable weight. Much of this is not necessary for the purpose, particularly when moderate loads are to be transported, as is usual with work done on the floors above the first; and all excess of weight is not only detrimental, as unnecessarily loading down the building, but adds needlessly to the expense. In fact the principal requirements of a floor track would seem to be these: First, it should be on a level with the top of the floor, so as not to offer any obstruction to the workmen going from place to place, or to the passage of hand trucks over it. Second, it should be of such moderate weight that it may be laid down on any floor of the building without overweighting it. Third, it should be of such simple construction that an ordinary mechanic may build one, put it in operation and repair it. Fourth, it should be so designed that cars having a fixed wheel base may readily run around its curves without undue friction. Fifth, it should be of such depth that it may be easily laid down by cutting through the usual two-inch plank floor of the ordinary machine shop, or laying the

track first in the case of a new shop being erected, and fitting the floor around it.

A track designed and constructed in conformity with these conditions is illustrated in the drawings accompanying this chapter. Fig. 132 is a plan of a section of straight track joined and secured to a 90-degree curve. Fig. 133 is a section of straight track in connection with a left-hand switch. Fig. 134 is a cross-section of the straight track, on an enlarged scale. Fig. 135 is a cross-section of curved track, also on an enlarged scale. All of these views show the track and its supporting timbers as arranged and laid in the shop yards. Fig. 136 is a cross-section on a still larger scale, showing the relation of the straight track and a portion of the rim of a car wheel. Fig. 137 is a similar section showing the position of the wheel on the outer rail of a curve.

Upon a straight track it is a simple matter to construct wheels or track that will run properly and work freely without undue friction or grinding upon the edges of the rails.

When the curves are considered quite a different problem presents itself. The outer rail upon a curve being considerably longer than the inner rail, means must be provided for compensating for this difference so that there may be no slipping of either wheel of the car when passing around the curve, in the case of the usual four-wheeled cars whose wheel axles are journaled in fixed boxes. To provide for this condition the groove in the track is considerably widened, whereby the wheel flange may have ample space to run from side to side. The wheel is constructed with an inclined face, representing a short section of a cone. It is considerably wider than the portion of the track upon which it runs, as will be seen by referring to Figs. 136 and 137. The action of this arrangement is as follows: When running on a straight track the position of the wheels on the track will naturally be midway, in consequence of the reversed position of the inclined tread of the wheels. When the car arrives at a curve the natural tendency is toward the outer rail. This tendency will throw the outer wheel up on its largest diameter and at the same time bring the bearing of the wheel on the inside of the curve to its smallest diameter. This variation of diameters will be sufficient to compensate for the increased length of the rail on the outer side of the curve and the car will run smoothly around it. The difference between the width of the groove in the straight track and that on the curves is arranged for by narrowing the groove in the curved track to the proper width in the final 8 or 10 inches from the end where it joins the straight track. The dimensions of the track are given in Figs. 136 and 137.

All curves are of 12 feet radius to the inside rail of the curve, and it would be better to make them 14 feet if possible, as the longer the radius the easier the cars will go around the curves, no matter what system of construction of

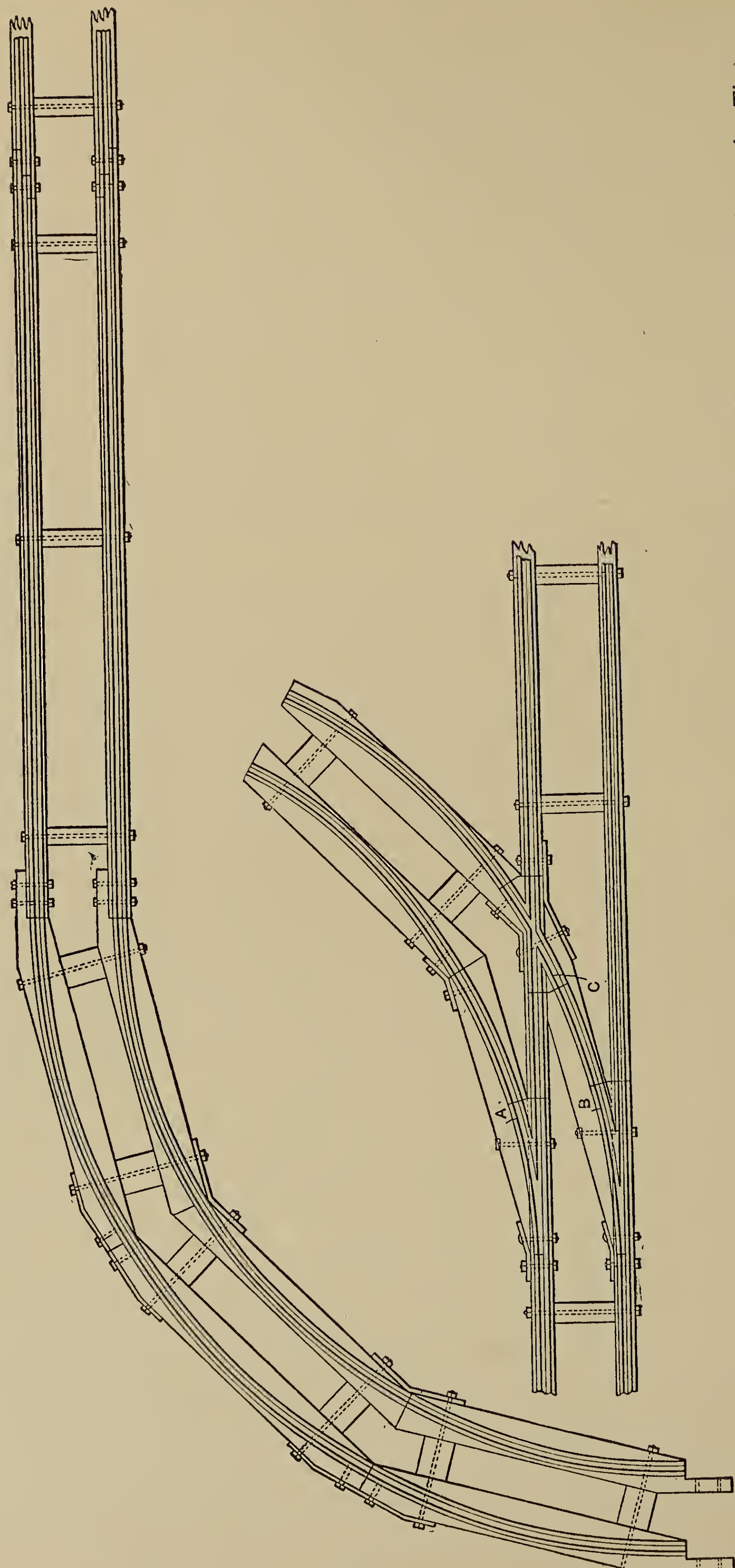


Fig. 132. — Plan of Curve and Straight Track, showing Method of Joining.

Fig. 133. — Plan of Switch, showing Method of Securing Supporting Timbers.

cars is used. For switches the plan will be as shown in Fig. 133. Special castings are constructed as shown at *A*, *B*, and *C*, and to these the curved and the straight track will be joined as shown. Of course, these special castings must be made for right and left switches, necessitating two patterns of each piece. A shifting tongue to the switch need not necessarily be provided for cars carrying light loads, as it is a comparatively easy matter to guide them as desired. These yard tracks are laid upon timbers which are bedded in

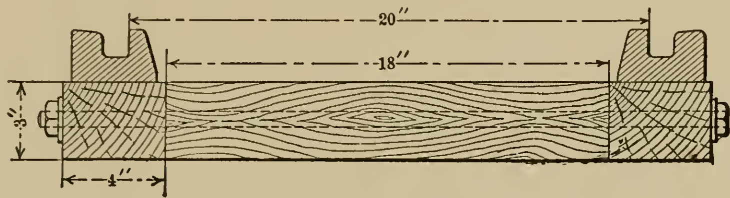


Fig. 134. — Cross Section of Straight Track when Laid.

flush with the top of the ground. For the straight track they are 3 x 4 inches and secured, as shown, by cross pieces and through and through bolts $\frac{5}{8}$ inch in diameter. For the curves 3 x 10 inch timbers are needed, and they are similarly fastened. In attaching the straight sections to each other the timbers are lapped and bolted as shown. On the curves, switches, and similar places, iron straps fastened by bolts or lag screws are used to connect them, as shown in the drawing.

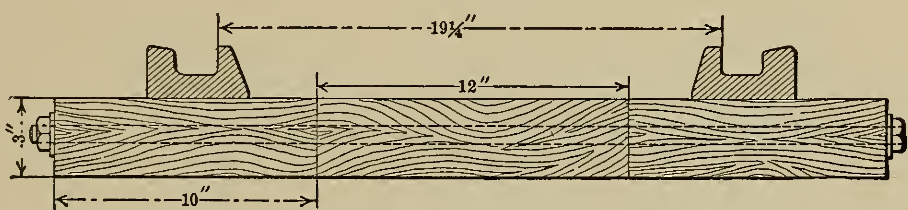


Fig. 135. — Cross Section of Curved Track when Laid.

In laying the track, the frogs and crossings of the switches should be first put in place and connected with the straight pieces of track, which may be easily cut to length on the power hack-saw. Such curves as are necessary to connect the switches to the straight track are then put down, care being taken to have the proper pieces of curved track to connect with the straight track so as to properly fit the groove in it. It will be necessary to have a gage by which to locate the second track, after the first line of rails has been put down and correctly lined up.

Another form of track is shown in Fig. 138, for the straight yard track. It has the advantage of having no groove where water, snow, or ice may find a lodgment and impair the usefulness of the system. This form of track may also be constructed for the curves, by placing it the proper distance apart to permit the wheels to run up on their largest diameter on the outside rail and their smallest diameter on the inside rail. Grooved track will be needed at the switches.

In fastening down these tracks heavy, flat-head wood screws are used for track having a groove, and lag screws for track constructed as shown in Fig. 138.

In Fig. 139 is shown another form of track for shop floors, letting the rails in flush with the top of the floor. The sides of the track are square with its lower surface, so as to have it fit up to the edges of the floor planks without cutting them to an angle. Curved track is similarly made, the groove being wider but the edges of the track vertical, as shown.

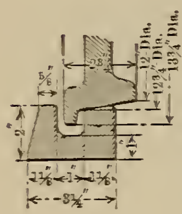


Fig. 136. Cross Section of Straight Track.

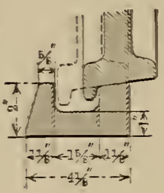


Fig. 137. Cross Section of Track on Curves.

It will be noticed that all this track is of cast iron, as being a cheap and convenient material. Steel rails laid on ties may be used for the straight track if desired, and cast iron rails for the curves and the switches, but the expense will be considerably more, and the additional outlay is not necessary if light loads, say under two tons, are to be carried.

Fig. 140 shows a plan and cross-section of a turntable. It is composed

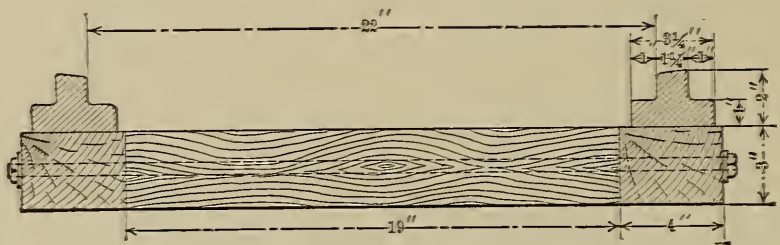


Fig. 138. — Cross Section of Straight Yard Track.

of two castings; the lower one, or bedplate, being, for convenience, made of octagonal form, and having formed in it a proper recess for receiving the turntable proper, which is journaled or pivoted upon a center pin cast upon the bedplate. Two annular bearing surfaces are provided, in addition to the boss around the pivot pin. At the ends of the track grooves are formed

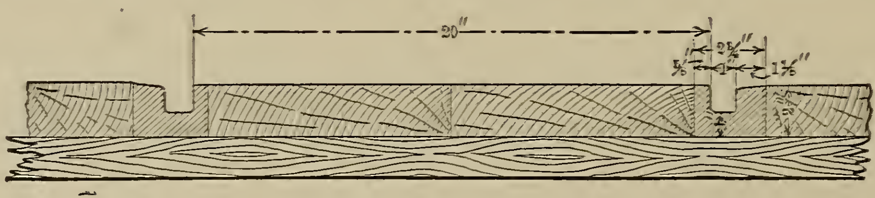


Fig. 139. — Cross Section of Straight Shop Track

suitable pockets for receiving the ends of the track and holding them in line with the turntable grooves. At one side is shown a simple and convenient latch, *A*, pivoted flush with the top of the bedplate in the projections, *B*. Four recesses are formed in the top of the turntable proper, into any one of which this latch may be dropped as desired. For heavy loads the annular

bearing surfaces are sometimes provided with grooves and hardened steel balls introduced to eliminate a large percentage of the friction, but in this case the additional expense is hardly necessary, if the bearing surfaces are kept well slushed with a thick grease. It will be better to face up the bearing surfaces in a large lathe that they may be true and evenly bearing surfaces, but this may be omitted if castings can be had which are straight and true. Where these turntables are used in yards, holes should be left in the bedplate casting to permit the water to run through, and thus avoid as much as possible the danger of their freezing up. The bedplate should be supported by 3 x 5 inch timbers placed directly beneath the tracks in both directions, these being usually used in connection with tracks at right angles to each other.

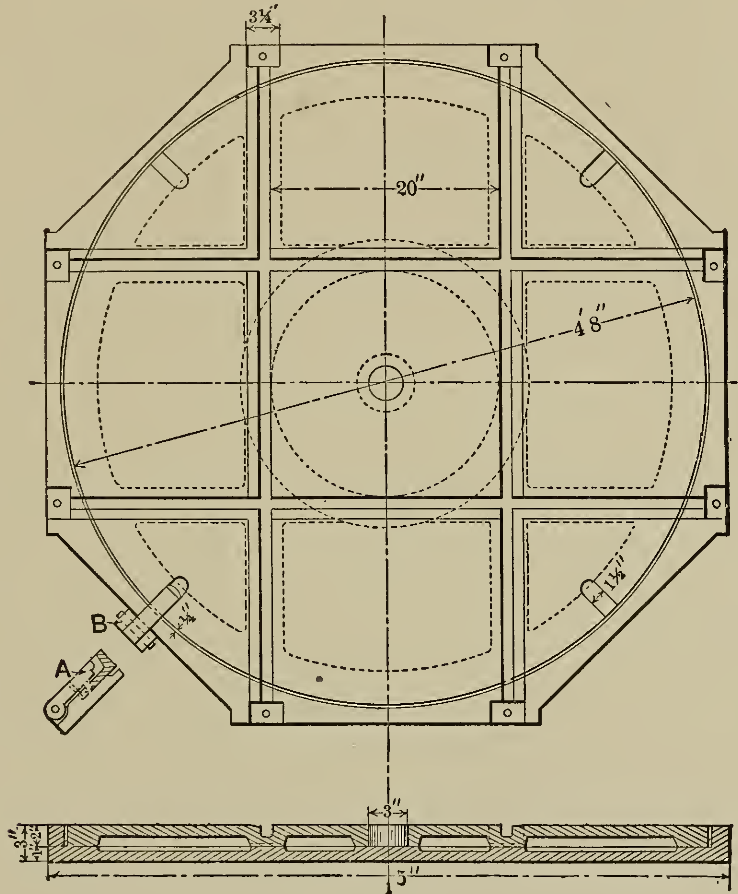


Fig. 140. — Plan and Cross Section of Turntable

It will be noticed that all of this track work is so simple and plain that the work of laying it may be done by any good carpenter; and that the effort is made to have all the arrangements of both track and cars of the most simple and inexpensive character consistent with utility and durability.

A car suitable to run on these tracks is shown in the drawings, in which Fig. 141 shows a side elevation; Fig. 142 an end elevation; Fig. 143, a bottom view; and Fig. 144, a section of one of the wheels, with a portion of the axle. Sufficient dimensions are given to enable any good mechanic to construct them. This car, constructed of oak planks, put together in the manner

shown, will be amply strong for loads up to two tons. The top planks are fastened down with $\frac{5}{8}$ x 4 inch lag screws, the heads with washers under them, and let in flush with the top of the planks so as to offer no obstructions. The frame is fastened, as will be seen, with $\frac{3}{4}$ x 6 inch machine bolts, the nuts of which are placed in mortises. The axle boxes are solid and fastened to the car frame by $\frac{3}{4}$ x 4 inch lag screws, and are also held rigid by ribs let into the side timbers, as shown.

So far we have considered only the plain platform car, which will be

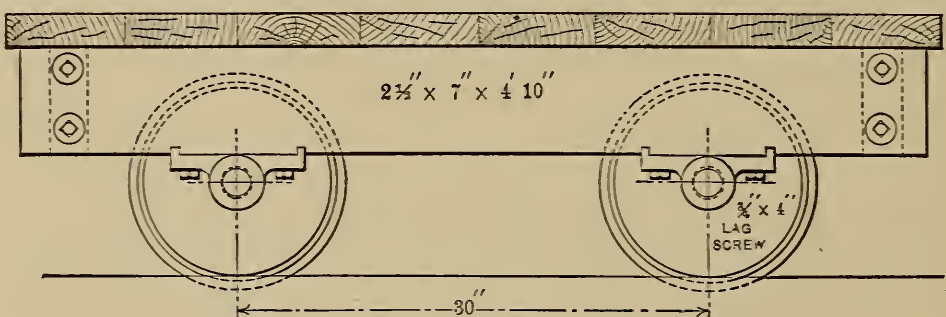


Fig. 141. — Side Elevation of Tram Car.

used for perhaps a majority of the transportation of material and stock about the plant. But there will be a demand for cars for special work, where a car of special construction and adapted to the conditions will be vastly more convenient, and better suited to the purposes for which it is used. As it has been the aim in designing and arranging this system of shop and yard tracks, and the necessary equipment for them on such a plan, that all the work of construction and installation may be done on the premises, and at moderate expense, the same idea has been carried out in reference to what may be dignified in railroad parlance as the "rolling stock" or equipment for it. With this idea in view, the different styles of cars represented in Figs. 145, 146, 147, 148, 149, 150, and 151 have been designed to meet the requirements of actual practice in the regular routine business of the machine shop and the various departments necessarily connected with it.

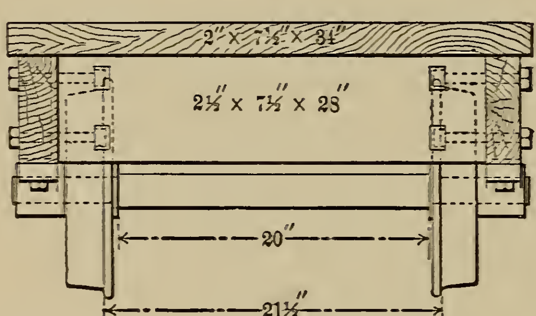


Fig. 142. — End Elevation of Tram Car.

The plain platform car, suitable for use in the shops, was seen in Figs. 141, 142, 143, and 144. This form is the basis of all the cars shown in the succeeding illustrations. Fig. 145 shows a car with stakes, supported in ordinary cast iron stake pockets bolted to the frame of the car, proper recesses having been cut in the top planking or platform of the car to accommodate them. These stakes may usually be 20 to 24 inches in height from the top of the car

platform, and $2\frac{1}{2}$ x 3 inches at the largest part. Such a car will be useful for transporting lumber in long or short lengths, for forgings, for small boxes, or bundles of manufactured stock to be shipped, as well as many other uses which will readily suggest themselves.

In Fig. 146 is shown an ordinary platform car having a box of $1\frac{1}{2}$ to 2

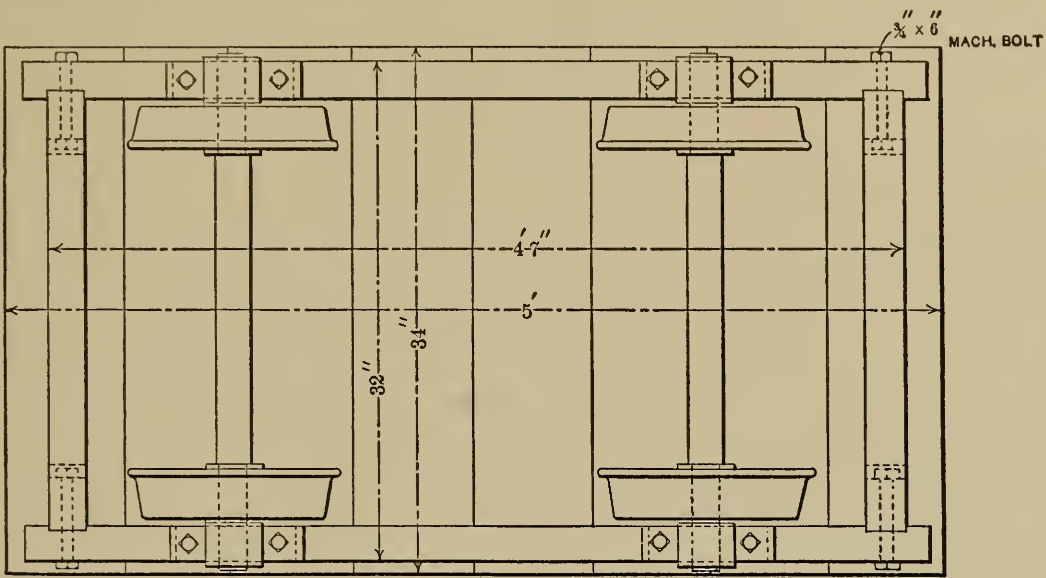


FIG. 143. — Plan of Under Side of Tram Car.

inch plank, held together by $\frac{5}{8}$ rods, as shown, and held in place on the car platform by the straps *A A*, so as to be readily removable and adaptable to any of the regular sized cars. This form of car is very useful in transporting lots of small castings, forgings, drop forgings, partially finished work, and any kind of stock and material which may be handled roughly and is not too large or clumsy for piling in such a box.

Fig. 147 shows a car specially arranged for transporting spindles, short shafts, and similar work which have been finish turned, ground, or have passed through such operations as render their careful handling necessary. In this case a sub-base of $1\frac{1}{4}$-inch plank is placed two or three inches above the car platform, and a similar one at a proper height above it to accommodate the work to be handled. These supporting planks are perforated with holes of a proper size to suit the work. They are supported and held in place by plank ends, corner posts, or in any convenient manner. These supporting shelves or frames may be attached to the car as a part of it, or they may be made removable like the box shown in Fig. 146. This form furnishes a safe and convenient method of handling this class of work.

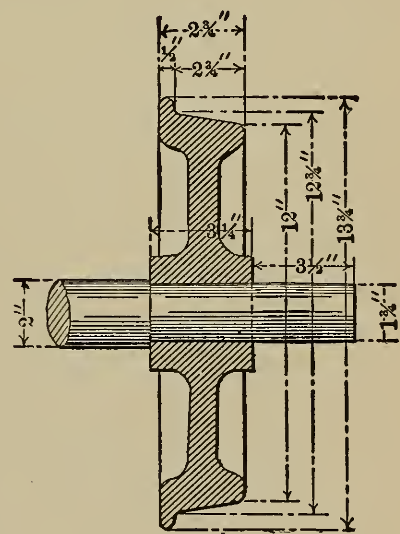


FIG. 144. — Section of Car Wheel.

Fig. 148 shows a car arranged with racks for holding a series of trays for the reception and transportation of small, finished parts, or parts going from the machines to the polishing room, plating room, finished parts storeroom, etc. Such cars may be constructed to take trays the full size of the car platform, one half, or one third of it, or for any combination of these sizes, the trays sliding into their places like the printer's type cases. They will be found very convenient for handling and for accounting for small parts in their transit through the shop.

Figs. 149 and 150 show a dumping car, arranged from one of the regular

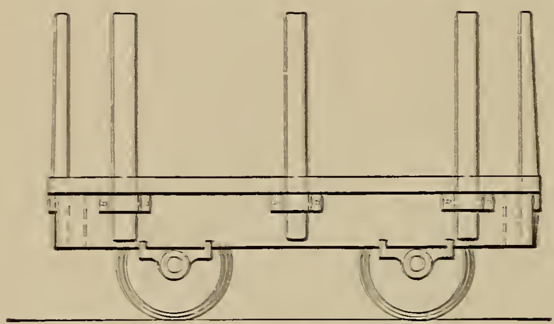


FIG. 145. — Car with Removable Stakes.

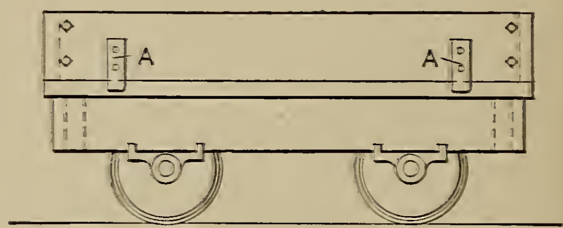


FIG. 146. — Car with Removable Box.

cars, with the platform omitted. As will be seen, the box or body of the car is not pivoted upon trunnions, but supported upon a cast iron rack, with cast teeth, at each end of the car, this rack being engaged by a toothed segment fixed to the car body as shown. The object of using this toothed device in preference to simple trunnions or pivots is to carry the car body toward the side where the load is to be deposited when the car is dumped. The device

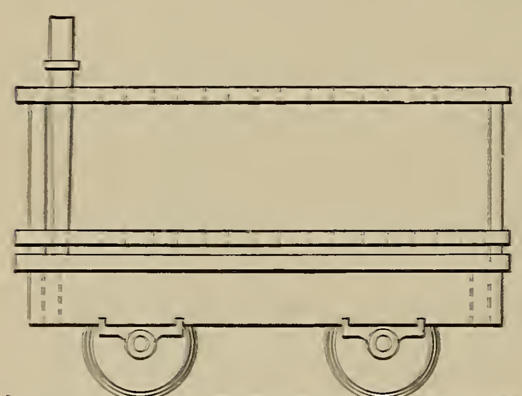


FIG. 147. — Car Arranged for Special Work.

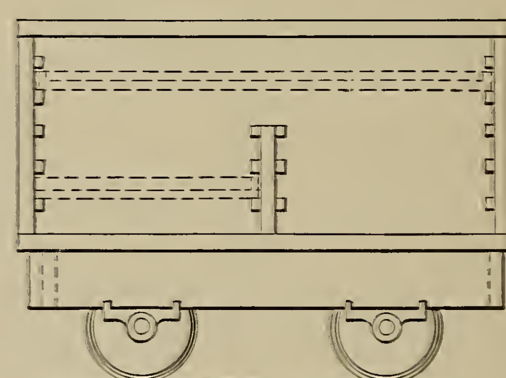


FIG. 148. — Car Arranged for Trays.

is simple and effective. The side supports, *A A*, are pivoted to the frame of the car and are used to hold the car body in its normal position. The sides of the car body are pivoted at the top, as shown in Fig. 150, and held or released by a simple latch at their lower edge. A small safety chain may be added on each side to prevent the car body from becoming unshipped by careless dumping.

These cars may be used in transporting coal, ashes, coke, molding sand,

and all similar materials which may be quickly unloaded by dumping. Those used for carrying coal to the boiler room may have a horizontal shelf on a level with the bottom of the car body, and on the side toward the boilers. However, a more convenient arrangement will be a solid box of three sides, or two ends and a side, built upon an ordinary platform car, the side toward the boilers being pivoted at the bottom instead of at the top, as shown. This will be convenient to shovel coal from. But the dumping car, as shown, should be used for the removal of ashes. For either coal or ashes the car bodies should be lined with sheet iron.

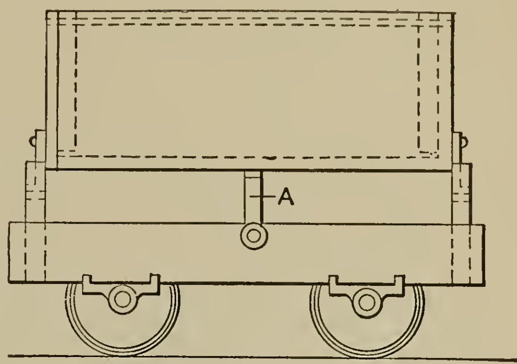


FIG. 149. — Side Elevation of Dump Car.

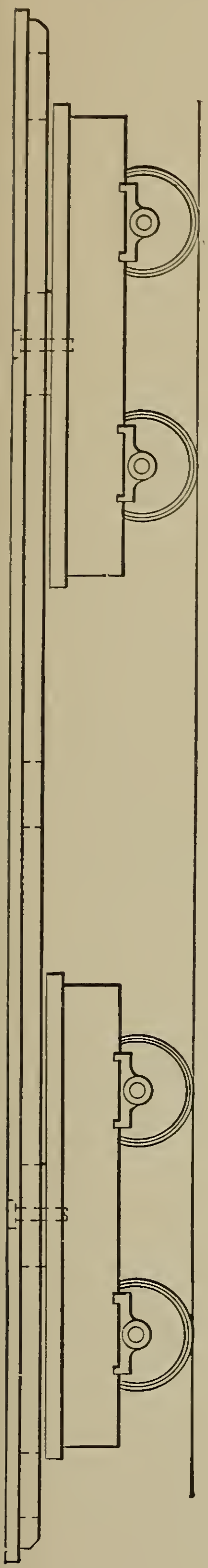


FIG. 151. — Double Car. Two Cars and a Special Platform.

Fig. 151 shows a large car formed by placing upon two ordinary flat cars a platform constructed of 2-inch planks, running lengthwise, and held together by cross bars $2\frac{1}{2}$ inches thick, and a similar bar running lengthwise on each side of the platform, and within two inches of its edge. Such a platform may be from 34 to 42 inches wide, and from 7 to 10 feet in length, according to what use it is intended for. Cross bars at least 12 inches wide should be built with the platform, at the points over the centers of the cars, and through these is placed a "king bolt" as shown, which furnishes a pivot upon which the separate cars turn, the same as the trucks of a railroad car. It will be readily seen that such a car will carry double the weight of the ordinary platform car as the weight is distributed upon eight wheels instead of four.

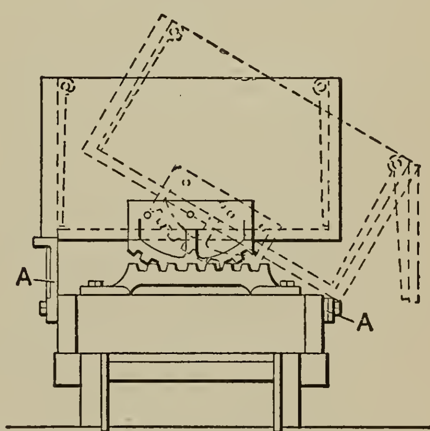


FIG. 150. — End Elevation of Dump Car.

Cars for use in the yards may be heavier and longer than those used in the shops if the conditions demand such increase. For instance, the cars may be made 38 inches wide and 6 feet long instead of 34 inches by 5 feet.

The frames should then be of 3 x 8 inch instead of $2\frac{1}{2}$ x 7 inch timbers. The wheel base should remain the same, in order to facilitate the passage of the car around the curves.

As to the number of cars necessary for the equipment of the entire plant, much will depend, of course, upon the particular character of the work to be done, but in a general way it may be stated somewhat as follows: Of the ordinary flat cars, as shown in Figs. 141, 142, and 143, there will he needed 16 cars, distributed among the different departments. Of these, 6 at least should have stake pockets and a sufficient number of stakes provided for them to give ten stakes to a car. There should also be 10 of the removable boxes shown in Fig. 146 for use on them if needed. There should be 6 dump cars for use in the yard, foundry, and boiler house. The special cars shown in Figs. 147 and 148, and such modifications of them as may be necessary, will be used mostly in the machine shop galleries, and their number will be determined to a very large extent by the kind of work that is to be done. There should be at least two of the platforms shown in Fig. 151, to be used on any of the flat cars. The number of cars above mentioned is considered really essential to the proper handling of the usual classes of stock and material, but a larger equipment will doubtless be advisable whenever the first cost is not closely limited, as a lack of proper transportation facilities, while there may be a saving in first cost, will prove a matter of continual expense in not being able to handle stock and material to advantage, and with the economy of labor cost that a complete equipment would permit to be done with ease.

CHAPTER XXIV

MISCELLANEOUS EQUIPMENT OF THE MANUFACTURING PLANT

The smaller departments. The importance of minor details. The experience of practical men. The carpenter shop. Arrangement for storing lumber for daily use. The foreman's office. Its construction and arrangement. A fixed desk. Foreman's store-room. Convenient bins for nails, bolts, etc. Cutting-off saw. Swinging Saw. Rip saw. Work benches. Shop doors. Shop track. The storehouse. Steam railroad track. Wide doorways. The floor arrangement. Overhead trolleys and hoists. Plan for storing machines. Painting machinery. So-called enameling paints. Avoiding the expense of a painting department. The paint room. The general wash rooms. Separate entrance and exit doors. The lockers. Construction and arrangement of the wash rooms. The general water-closets. Construction and arrangement. Sanitary care of wash rooms and water-closets. Building machine foundations. A planer foundation. The necessities of the case. Excavations. The plans for the work. The central pit. Strong mortar necessary. Setting up the planer. Foundation requisites.

In this, the concluding chapter of this portion of the work, it is proposed to take up the smaller departments, special rooms, etc., in the same manner in which the subject has been treated in the previous articles and to give such a detailed description in connection with the engravings as to make the matter as complete as in any of the more important departments of the plant, and finally to give an example of machine foundation more complete than the brief description in Part First of this book.

To many casual readers, or superficial observers, who may have read these chapters it has doubtless appeared that very many of the matters considered have been treated with too great a regard for the smaller details and the minor points which, in their way of thinking, might be easily decided and disposed of at any time without much study as to just how this or that matter could be best handled, or this convenient accessory be best located, arranged, or equipped. This ignoring of details, assuming them to be trifling matters, has often been the cause of much disappointment and useless expense, because what was, at the time, considered a trivial matter has, under perhaps somewhat unusual conditions, and sometimes under the most ordinary conditions, proven to be much more important than at first supposed, and given no end of trouble

before being finally arranged in a thoroughly and practically satisfactory manner.

To practical men who have had experience in the designing and arranging of the various machine shop departments and accessories, or of those of a manufacturing plant, so as to afford the best accommodations and facilities for the class of business to be done there, at a reasonable economical expense, and to those who have had years of practice in superintending and managing the daily routine therein, it has doubtless occurred that there were many points in these chapters that should have been much further elaborated, and whose details should have been gone into more thoroughly and explicitly. For these men know the annoyance, the disturbance of daily routine work, the inconvenience and the expense of alterations, changes, and rearrangements that it has been their lot to encounter and their duty to remedy, in order tc

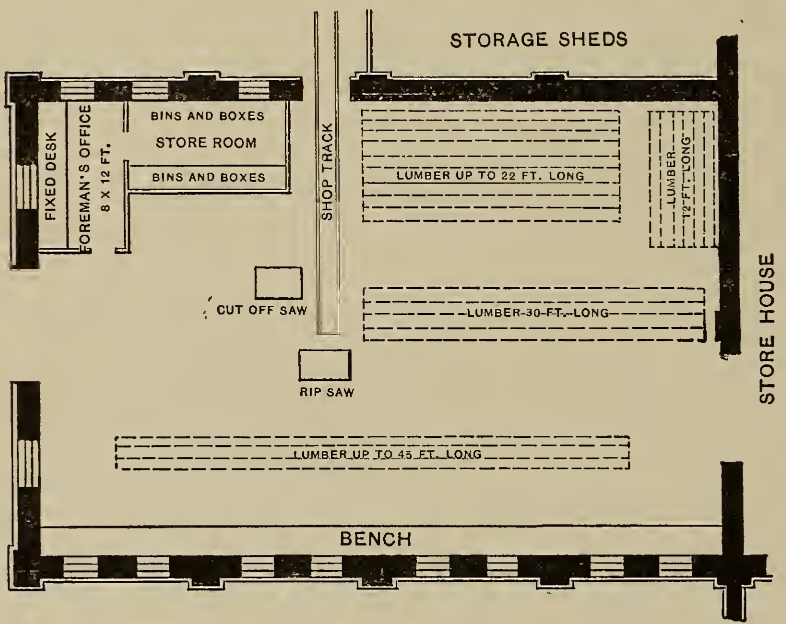


Fig. 152.—Plan of Carpenter Shop.

bring efficiency out of the ill-advised and impractical plans and get everything running smoothly and satisfactorily.

The carpenter shop is located near the rear of the plant, between the machine shop proper and the forge shop, and adjoining the storehouse, or shipping room. Its internal arrangement is shown in Fig. 152. In this department should be stored the lumber and other packing material necessary for shipping, as well as for doing the miscellaneous carpenter work required about the plant. This material may be brought in on the yard cars by way of the track entering the side door; or, if received by the steam railroad cars, it may be brought in through the storehouse — a distance of only fifty feet.

Lumber in long or short lengths will probably come in on the steam railroad cars, as it should be purchased in carload lots. It may be unloaded

upon the yard cars at the rear gate and run directly into the carpenter shop. Convenient methods are shown, by dotted lines, in the engravings for locating the different lengths of lumber so as to render any length accessible without disturbing any other length. Ordinarily the lumber will be piled on the floor, but light, thin lumber, matched sheathing, etc., may be placed in racks overhead, where it will be more out of the way and safer from accidental injury. Box stuff cut to dimensions, as well as made-up boxes, may be similarly stored so as not to unnecessarily encumber the floor space.

In the outer corner of the shop is an inclosure serving as an office for the foreman. It is built of $\frac{7}{8}$-inch matched sheathing to the height of 42 inches, and above this height it is composed of a galvanized iron wire netting 4 feet wide and of 1-inch mesh, attached to a frame of 2 x 3 scantling, placed not over five feet apart, and forming also the framework supporting the sheathed portion below. The wire netting is tightly strained upon this and fastened with 16-ounce tacks, after which a face casing $\frac{1}{2}$ inch thick and 3 inches wide is put on, along the top and bottom and vertically at each upright. A cap 1 inch thick and 3 inches wide is placed on top. At the top of the sheathing a 1 x 2 inch strip forms a cap, underneath which a $\frac{1}{2}$ x 1 inch strip forms the finish. Doors may be conveniently made with side and top stiles 1 inch by $4\frac{1}{2}$ inches, and the middle and bottom stiles 1 inch by 6 inches, all "halved together," glued and screwed, and covered with the wire netting, and finished with a facing strip $\frac{1}{2}$ inch by 2 inches, mitered around each panel to cover the edges of the wire netting. These are very strong and quite light and answer the purpose admirably. The object of constructing inclosures in the shop in this manner is to obtain a reasonably secure partition, and at the same time one that will offer as little obstruction to the light as possible, and also permit as free observation of the various parts of the room, as well as of the inclosure itself. This method has been found in practice to be strong, durable, and economical.

Along the side of this inclosure, next to the wall, is a fixed desk of proper height for a man standing, say 41 inches. It should be 24 inches wide and incline to the front about 2 inches in its width. Upon it, and in the corner between the two windows, should be placed a suitable pigeon-hole case, not over 24 inches high and $8\frac{1}{2}$ inches deep. The top, bottom, and sides are of $\frac{7}{8}$-inch white pine and the partitions are of $\frac{1}{2}$-inch stuff. This, with the desk, should be protected by two or three coats of shellac varnish. This case will be used for holding such blanks, slips, memoranda, and similar papers as are in use. Proper space should also be provided for the necessary books relating to the carpenter work, boxing, skidding, shipping, and similar work.

At the left-hand side, and between the window and the partition, there should be fixed to the brick wall a board of the same height as the pigeon-hole

case for convenience in hanging filing clips and for similar purposes. Beneath the desk should be two drawers, about 5 inches deep, 24 inches from front to back, and 30 inches wide, and provided with locks. Such an arrangement of desk, pigeon-hole case, drawers, etc., is shown in Fig. 153, which will give a general idea of its appearance and usefulness as well as of its economical construction.

The particular description here given of such fittings as these will apply to the design, arrangement, and construction of similar cases, racks, shelves, and other divided spaces necessary in many other parts of the plant, and we shall be well repaid for the time spent in carefully designing them to meet the special conditions and objects for which they are to be used, and shall often

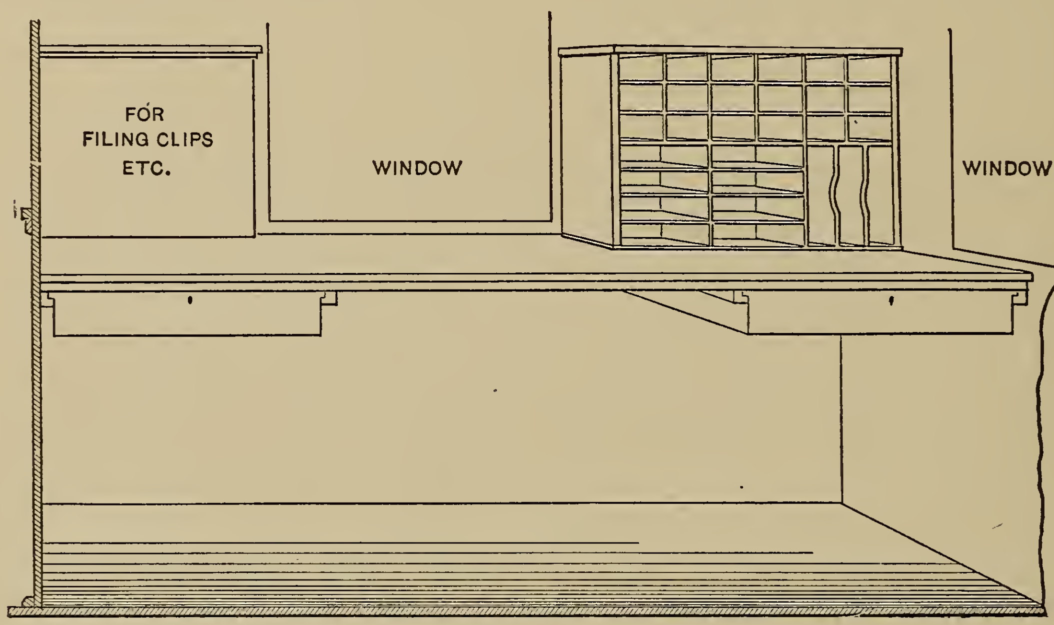


Fig. 153.—Fixed Desk, Pigeon Holes, etc.

be enabled thereby to save quite a percentage of the time of the employees using them. They may be constructed by any good carpenter and will be in many respects the best as well as the most useful.

Adjoining the foreman's office and opening out of it is a similar inclosure, to be used as a storeroom for the carpenter shop and to hold such articles as may be much more conveniently kept here than in the principal storeroom, in the office portion of the plant, to be drawn in small quantities as needed.

Against the wall is a case containing a row of bins for holding nails, spikes, etc. They are constructed of sufficient dimensions to hold a liberal supply of each size of nails and spikes, and the front board is made quite narrow, not over 6 inches high, to facilitate the removal of the contents. Above this row of bins is a case for lag screws, etc., containing thirty-five boxes, this being amply sufficient for all the different sizes usually needed. The width of this case is determined by the distance apart of the two windows

between which it is located. At the left of this case, standing on top of the bins, and in front of the window, should be a small counter scale for weighing such articles as may be used or issued and are to be accounted for by weight. A perspective view of this case and the row of bins is given in Fig. 154.

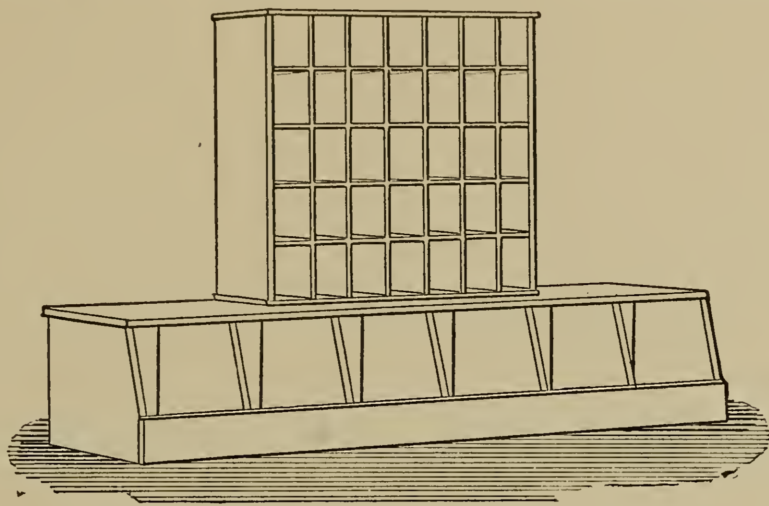


Fig. 154. — Case for Lag Screws, Nails, Spikes, etc.

On the opposite side of the storeroom is a somewhat similar case for holding nuts, washers, etc., in the bins, and having above it a case with forty-two compartments for machine bolts, carriage bolts, etc. A perspective view of this case is given in Fig. 155. Both of these cases are made of $\frac{7}{8}$-inch pine and painted. The top of the bins is 24 inches from the floor. That shown in Fig. 154 is 6 feet high, but the one shown in Fig. 155 is limited to 5 feet so as not to unduly obstruct the light. The base of the bins is 18 inches wide. The depth of the upper cases is $8\frac{1}{2}$ inches. In the construction of cases of

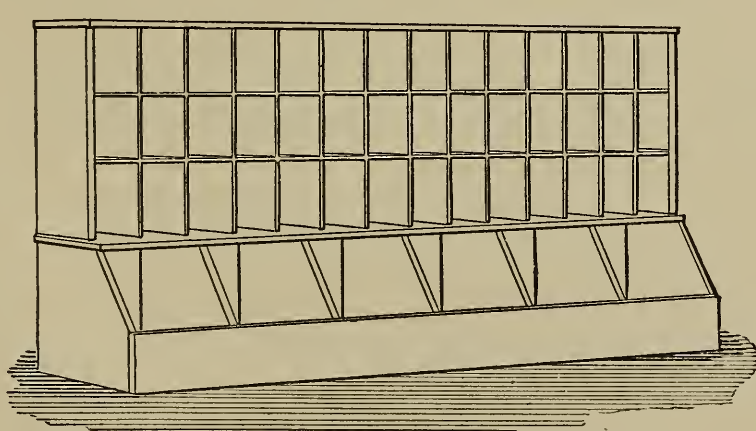


Fig. 155. — Case for Machine Bolts, Nuts, Washers, etc.

this kind it is well to remember that they may be made of an ordinary quality of pine commonly called "box boards," planed on both sides. The horizontal boards or shelves are first put in, the ends resting on cleats screwed to the uprights at the ends of the case. The upright partitions are cut to the correct length on the cutting-off saw, set in place and "toe nailed" in front, and

nailed through the back. All the shelves and upright partitions should be $\frac{1}{8}$ inch narrower than the uprights at the ends, while the top should project $\frac{1}{2}$ inch at the front and ends. The bins may be built in place, nailed to the floor, but it is sometimes desirable to have such fittings built separate and set in place when completed, so that they may be moved, in case it should be necessary to do so, without partially or wholly destroying them.

The location of the piles of lumber is indicated by dotted lines, and the capacity of the space is marked in each case. At the side of the yard track entering the carpenter shop is a cutting-off saw. This may be one with a sliding table, upon which the lumber to be cut is placed and moved toward the saw. But for rapid work a swinging saw, pivoted overhead, and quickly moved in an arc across the piece of lumber, is preferable for the ordinary rough work called for in the carpenter shop. Of course, such a saw must be carefully protected so that the careless use of it may not be dangerous to the workmen.

Near the cutting-off saw is the rip saw, but located at right angles to it so that long lumber may be handled, and in order to increase this capacity it is placed between the two doors, thus permitting the handling of lumber of almost any length. A work bench occupies the entire length of the inner side of the shop, furnishing an ample space for five men at bench work. It is fitted with removable vises in order that long work may be handled if necessary. A door 10 feet wide leads into the yard and one of the same width into the storehouse. These should be sliding doors, the latter a properly protected fire door. A side door 4 feet wide gives entrance to the tram track from the yard. In the large outer sliding door it is well to put a small swinging door, say 30 inches wide, for convenient use in winter, to avoid the necessity of opening the large door for the passing in and out of the workmen.

The storehouse adjoins the carpenter shop, communicating with it by way of the 10-foot fire door just mentioned, and with the rear end of the machine shop by a 14-foot sliding door, also arranged as a fire door. The relative position, as well as the complete plan, is shown in the engraving in Fig. 156. A steam railroad track runs along the rear of the entire plant, and as closely as may be to the shipping doors of the storeroom. These are three in number, one of 12 feet, and the other two 8 feet in width. Six windows in this side and four in the end of the storehouse afford sufficient light for the usual purposes.

The floor of the storeroom is raised above the floor of the machine shop to such a height that the top of the platforms of the cars running on the machine shop floor track will be the exact height of this floor. A portion of the floor of sufficient width to admit a shop platform car is cut out, as shown in Fig. 156. By this means machines may be placed on these cars by the traveling crane

in the machine shop, run into the storeroom and unloaded on the floor at the exact level with the top of the car platform. From here they may be taken on rollers (if they are skidded) or on machine trucks, and put in their proper places on the storeroom floor. At each of the three shipping doors there should be an I-beam extending out over the railroad track, upon which is mounted a trolley hoist, preferably operated by compressed air or electricity. These I-beams should extend back at least to the center of the storehouse and, better still, all the way across it. They may be connected by lateral I-beams, by curves, by turntables, etc., so that nearly all parts of the storehouse may be effectively covered. The lateral tram car tracks will prove a valuable adjunct to this system in moving machines from place to place on the storehouse floor.

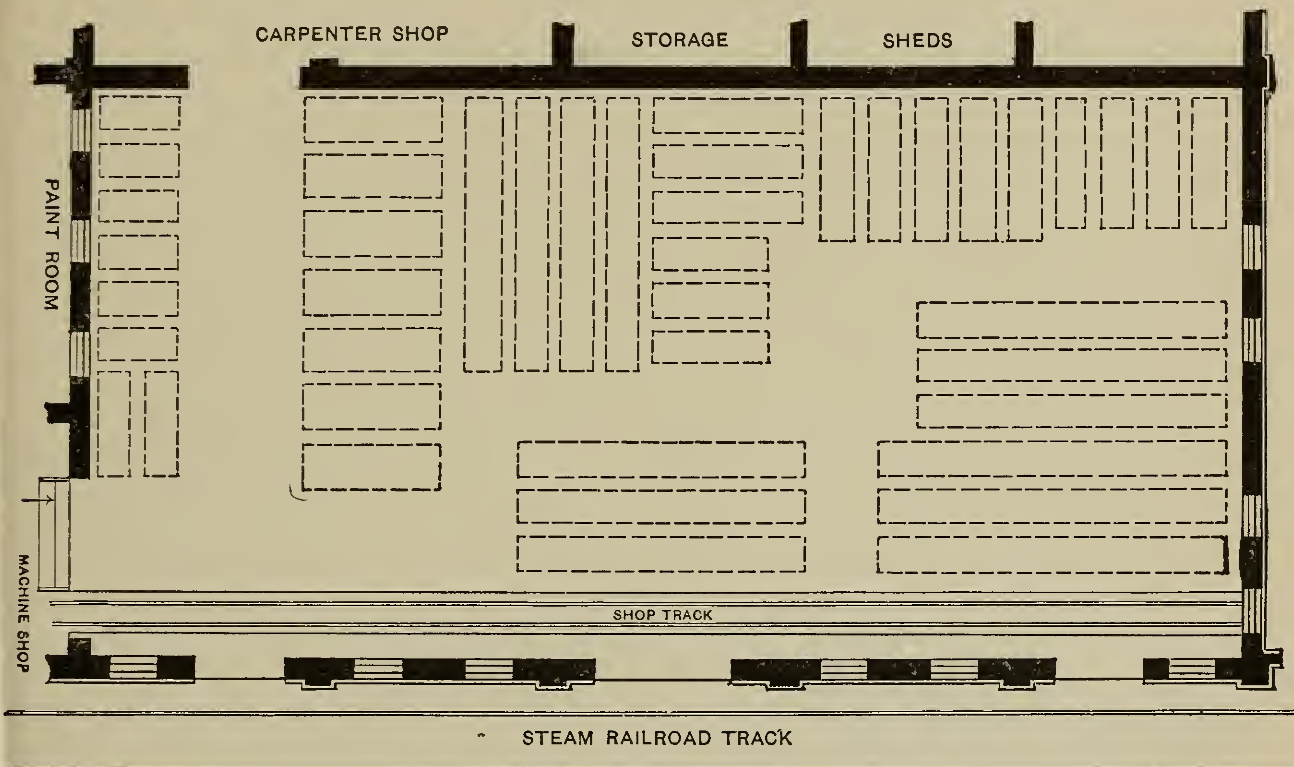


FIG. 156.—Plan of Store House.

In storing machines of various sizes in the storehouse while awaiting shipment it is frequently difficult to get at just the size of machine wanted without the trouble and expense of moving several others, for it is a common saying among shippers that "it is always the machine in the furthest corner that we want." In the dotted lines in the plan, Fig. 156, is laid out an arrangement of machines of a dozen different sizes, in such a manner that any size may be brought out for shipment without materially disturbing those of any other size. Of course this shows an arbitrary lot of sizes, but the plan here used, of reserving central aisles with cross aisles at proper intervals, is a plan which storeroom men and shippers will do well to familiarize themselves

with and to adapt to their special needs by changing it to suit the particular class of machines with which they have to deal.

In the case of small machines that may be stored on shelves, provision should be made for them by arranging shelving on the alcove plan, similar to that employed in storing patterns in the pattern storage room. In such cases such trucks as heretofore described in these chapters may be advantageously used, the truck wheels being located so as to fit the regular shop track. Manufactured machines may then be handled with very little labor of loading and unloading, the use of the overhead trolley being brought into requisition whenever possible. Branches from them may be run over the centers of the alleys between the sections of shelving as may be necessary.

In all manufacturing establishments making machines in whose construction cast iron enters considerably, there is more or less painting required. The present demand is for very clean, smooth work, finished with some one of the various machine enamels. These enamels, so called, are to a great extent composed of a pigment mixed with some kind of varnish, usually of gum copal, thus forming the "air-drying enamel," in contradistinction to the "baking enamel," so much used on bicycle parts and similar work. In the manufactory of the kind under consideration the machines will usually be of a size to render their removal to a special paint shop, and from thence, after painting, to a storehouse, a matter of considerable expense. They are, therefore, painted in the erecting departments, and the expense of providing a special painting department is avoided. Still there must be a safe and proper place for keeping paints, oils, and other painters' supplies and materials, and also to serve as a sort of shop for the painters.

This kind of a room is shown in Fig. 157. It is located between the storehouse and the machine shop. The floor should be of brick, hard asphalt, or concrete. On the side toward the storehouse are bins for holding dry colors. These should be raised 3 inches from the floor and be constructed of $\frac{7}{8}$-inch pine, similar in form to the bins in the carpenter shop storeroom, but with covers hinged at the top, for excluding dirt. On each side of the door is a bench 2 feet wide and 30 inches high, for convenience in mixing paints. Over each bench is a series of four shelves, 10 inches wide and placed respectively 12, 10, 9, and 8 inches apart from the bench up. These will be convenient for storing small cans of ground paints, brushes, sandpaper, and similar articles. Beneath the benches should be a shelf 16 inches from the floor, and each bench should be provided with a drawer 2 feet square and 8 inches deep, and furnished with a lock. The remainder of the space

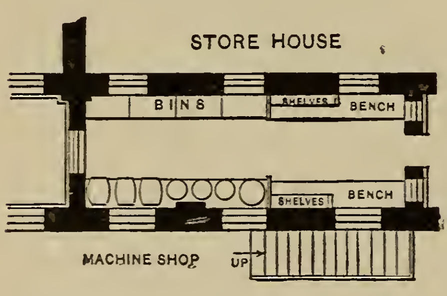


Fig. 157.—Plan of Paint Room.

on the side toward the machine shop should be provided with a platform 16 inches from the floor, for holding barrels of oil, turpentine, etc., on their sides, and for barrels of such dry materials as it is not desirable to put in the bins.

If considerable lamp black is used there should be a large galvanized receptacle, round or square, with a tightly fitting cover, for its storage, as there is always the danger of spontaneous combustion to be feared from it. Beneath the oil and the turpentine barrels there should be a drip pan of strong galvanized iron. The use of the lighter petroleum products such as gasoline should be avoided, if possible. If we are compelled to use them a separate storeroom should be built in the yard. It should have an iron roof, as a matter of ordinary protection. Any inflammable materials of this kind in use in the shops should be returned to it each night and taken out in the morning. The paint room should, of course, be always locked when none of the regular painters are working in it.

The wash rooms as well as the water-closets are located in the rear portion of the power house and upon each floor, the upper floor on a level with the floor of the machine shop galleries, this location being midway in the length of the machine shop proper, so within the most convenient distance from any point in the shop. There are two doors opening from the machine shop, one to be used as an entrance and the other as an exit door, to avoid the confusion that would otherwise take place if workmen going both in and out were to come in contact during the rush of the men in washing up and leaving the shops at quitting time. The plan is shown in Fig. 158.

A series of lockers are located on each side of the room its entire length, and a double row located in the center of the room. These, with a few at either end, will give one hundred and twenty-eight lockers in the room. There are, of course, an equal number in both the upper and the lower rooms. In some of the departments, for instance in the small parts storeroom, and the assembling rooms, — perhaps in the grinding room, the carpenter shop, etc., — the workmen may be provided with lockers in their work rooms, but the system can be better cared for by not breaking it up too much. Between the rows of lockers are the wash sinks, constructed after the plan shown in the chapter on iron foundry equipment, affording fresh, clean water to each man. The water used by the men for washing may be warmed in winter by passing it through a steam-heating coil, and the difference in the temperature of the water no doubt would be much appreciated by the men. When water is used for washing from a sink filled for that purpose a jet of steam opening below the level of the water will be a convenient means of warming it for the use of the men.

The windows along the outer wall of the wash room are placed high

enough in the wall to be above the lockers, which should be constructed of expanded metal, or its equivalent, but never of boards, or in any way to prevent the free circulation of air, and of sanitary cleanliness.

The water-closet room opens from the wash rooms. Windows open from each side, and there is an additional one at the far end. Those on the sides are placed high enough to be out of the way of the water-closets on one side and the urinals on the other. There are eighteen water-closets and twenty one urinals in the room. The urinals are divided by partitions 2 feet wide and 5 feet 8 inches high, and the water-closets are 32 inches wide and project 4 feet from the wall. Each

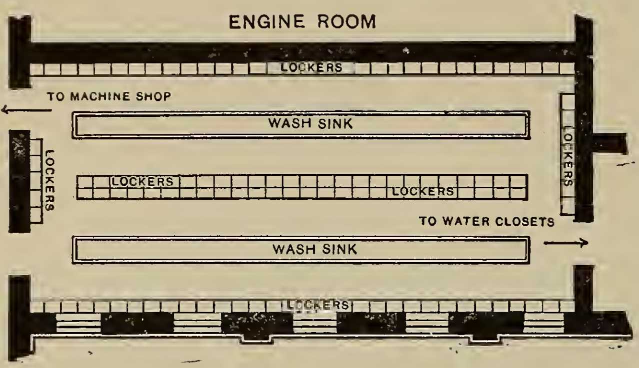


FIG. 158.—Plan of Wash Room.

closet is provided with a light door having double swing, spring butts, and a sliding bolt on the inside. These doors should not reach the floor by about 12 inches, and should extend to the top of the partition. The partitions should be 5 feet 8 inches high. A plan is shown in Fig. 159.

All partitions of the water-closets or urinals, if of wood, should be well painted with a heavy mineral paint, the last coat being of enamel, the preferable color being a steel gray, which is very hard and durable and will stand much washing. It will be better, of course, if these partitions are of metal, similarly painted. They may be of cast iron $\frac{3}{8}$ of an inch thick, strengthened by suitable ribs. For the water-closets wooden partitions will be preferable. The floor should be of some non-absorbent material with no seams or joints to retain offensive odors. A smoothly surfaced cement composition, such as is used for sidewalks, and commonly called "artificial stone" will be the best that can be put down at a reasonable expense. For the second story this may be laid, 2 inches thick, over a wooden floor composed of 3 x 4 inch scantling laid on edge. A similar floor will be suitable for the wash rooms, and much more economical in the long run than a wood floor, which will have to be renewed in a few years as it will decay from the constant wetting from the wash sinks.

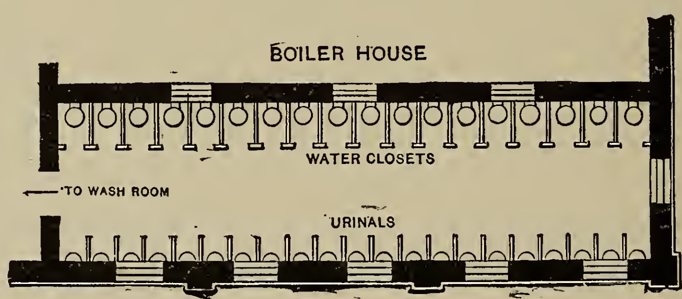


FIG. 159.—Plan of Water Closets.

On the ground floor the cement surface may be prepared for by broken stone, etc., similar to the usual shop concrete floor, only not nearly so deep.

All the piping for the water supply and for sewer connections should be in plain sight so as to be easily accessible when necessary to make repairs. The urinals should be automatically flushed with an ample supply of water at short intervals. The drainage pipes from the wash room should be utilized for flushing the sewer connections of the water-closets and the urinals. Water from the roofs of the buildings may be used for a like purpose, thus insuring a clear and ample drainage, free from the danger of clogging up the flow of water and the generation of sewer gas.

The water-closets and urinals provided for the machine shop will be used also by the carpenter shop and the storehouse employees, but these employees may have lockers located in the carpenter shop, if desirable, and they will doubtless be better satisfied with such an arrangement. The wash rooms and water-closet rooms should be in charge of an attendant whose duty it will be to see that everything is in proper working order and that sanitary regulations are strictly observed.

It would seem at this point advisable to say something more explicit about machine foundations than has been said in the chapter on this subject in Part First of this work. The planer has been selected as an example, and this for the reason that it is a machine tool upon whose accuracy much depends on the foundation upon which it is placed. This description is the result of much experience in this direction by the author, and will well repay the careful consideration of the men who may have charge of similar work.

The failure of machine foundations, even when built by experienced masons, is proverbial, and much money is frequently expended in this direction only to find the efforts end in failure again and again. It is an important subject for the mechanical engineer and no owner should attempt such work without the plans of an engineer who fully comprehends the particular case under consideration and prepares his drawings to fully meet the requirements.

With the constantly increasing demand for a much finer grade of work in all mechanical establishments; for more accurate fitting; for standard sizes; for practically perfect circular work where the circle is involved; for work that is to be square, to be at absolutely right angles; and for straight work to be as nearly absolutely straight as it is possible to make it; with the demand for machine tools of such construction and accuracy as was not thought necessary or hardly possible in the average machine shop of a dozen years ago — many of the standard machine tools, such as lathes, shapers, millers, and planers, have attained a degree of precision that seemingly leaves little to be desired in this direction. That these tools are expensive to build as well as to buy is one of the necessities imposed by this demand for accuracy. And it is met fairly, and the price is paid by all up-to-date establishments making even a pretense to producing reasonably accurate work.

Let us consider for a moment the application of this condition of demand and its successful supply in the case of a planer. It is certainly commendable, and shows a progressive spirit on the part of the management, to purchase the best and most accurately built planer in the market, as well as the one that will produce the greatest quantity of work — good work — work that one may have reason to be proud of and may not have need to apologize for.

But, having purchased the best planer the market affords, all conditions being equal, it becomes an important question as to the best method of setting it up so as to give the best results. Right here be it said that however much is paid for a planer, or however good may be the reputation of the establishment from which it is purchased, the machine will not do good work unless it is properly set up; unless it has a properly built foundation upon which it may be supported. And as a good price has been paid for a good machine, we must not expect a good foundation at a cheap price. Good things cost something, whatever they are.

Of the failures of foundations of the "good enough" kind many of us know all that we need. It is proposed to describe and illustrate a foundation that will properly fulfil all the requirements and conditions of the case. First, it may be well to call attention to some of the vital points involved in the matter.

It is best to have all planers on the ground floor. Small ones with extra heavy beds may be placed on an upper floor, but certainly those for work over four feet long should be placed on the ground floor.

All planers 30 inches square and 10 feet long, and over, should be set on special foundations.

All excavations for foundations should be carried down to "hard pan," or perfectly reliable, hard gravel bed, whether it be found three feet down, or ten feet.

All piers should be begun with quite large stone, laid as a wide footing, to the depth of from twelve to twenty-four inches, according to the depth of the foundation.

All foundations should be laid in strong cement mortar, by which is meant that containing two parts Portland cement, one part lime, and about three parts of clean, sharp sand. The amount of sand will vary considerably with its fineness, sharpness, and freedom from dirt. The finer the sand, the greater the quantity necessary. The spaces between the piers and between the walls and the surrounding earth should be tightly rammed with hard gravel, if it can be had. It will be well to use a hose and plenty of water in "puddling" this gravel in as closely as possible, as much support may thus be given to the masonry.

In the engraving, a foundation is shown for a planer 48 x 48 inches x 18

feet. Fig. 160 is a vertical, longitudinal section of the foundation, and Fig. 161 is a plan. Substantial ground is supposed to have been found at a depth of five feet, and upon this the stone footings for the piers are laid, two and a half times the width of the stone cap, and a proportionate increase in the length of the piers. This stone footing is laid two feet deep, and upon it the brick piers are built with a "batter" of 2 inches to the foot.

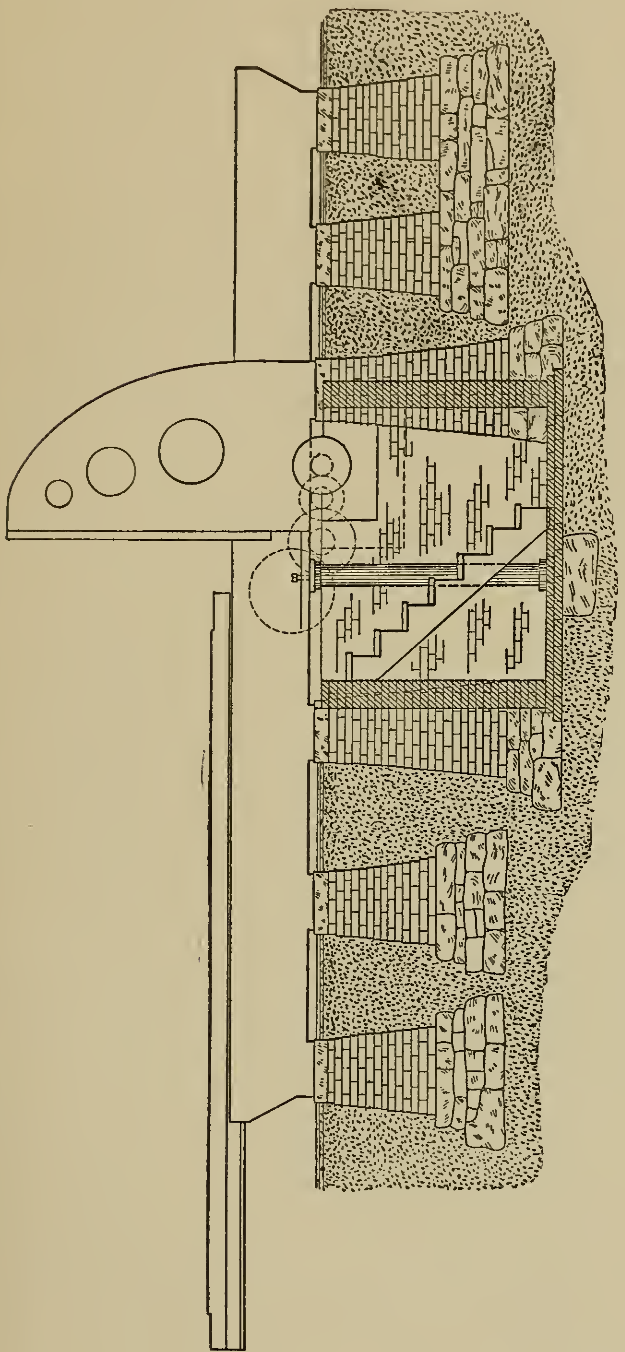


Fig. 160.—Vertical, Longitudinal Section of Planer Foundation.

In laying the bricks each course should be completed separately, and not by building a shell of one width of brick around the outside for several courses up at a time and filling in with brickbats and wide joints. In raising the corners not over three courses are built up, as cement mortar sets rapidly and it is very important that the work should be bound together as closely and strongly as possible.

Flush joints should be insisted upon in all machine foundation work. All piers should be capped with stone of fairly even thickness and perfectly level on the upper side.

In the center a pit is built as shown in the engraving. It should be six feet deep and extend from the pier beneath the rear of the side posts or housings, to a point far enough in front of the center gear to admit of free access to it in case of needed repairs. This pit should be wide enough to admit of placing in it wooden removable steps as shown.

On each side of the planer, pockets should be built for the pulleys, in case the planer is supplied with pulleys extending below the floor line. These pockets should be of such size as to permit the pulleys to be slipped on and off at the end of the shaft, and at least twelve inches wider than the diameter

of the pulleys. In this case they are shown for a planer having pulleys on both sides.

As nearly in a vertical line with the cutting tool as may be are two hollow columns, usually made of heavy cast iron pipe, resting upon the brick floor of the pit, reinforced at these points by a large, well set stone. These columns support the planer bed at the two points, the weight being taken by heavy adjusting screws and a sole plate as shown.

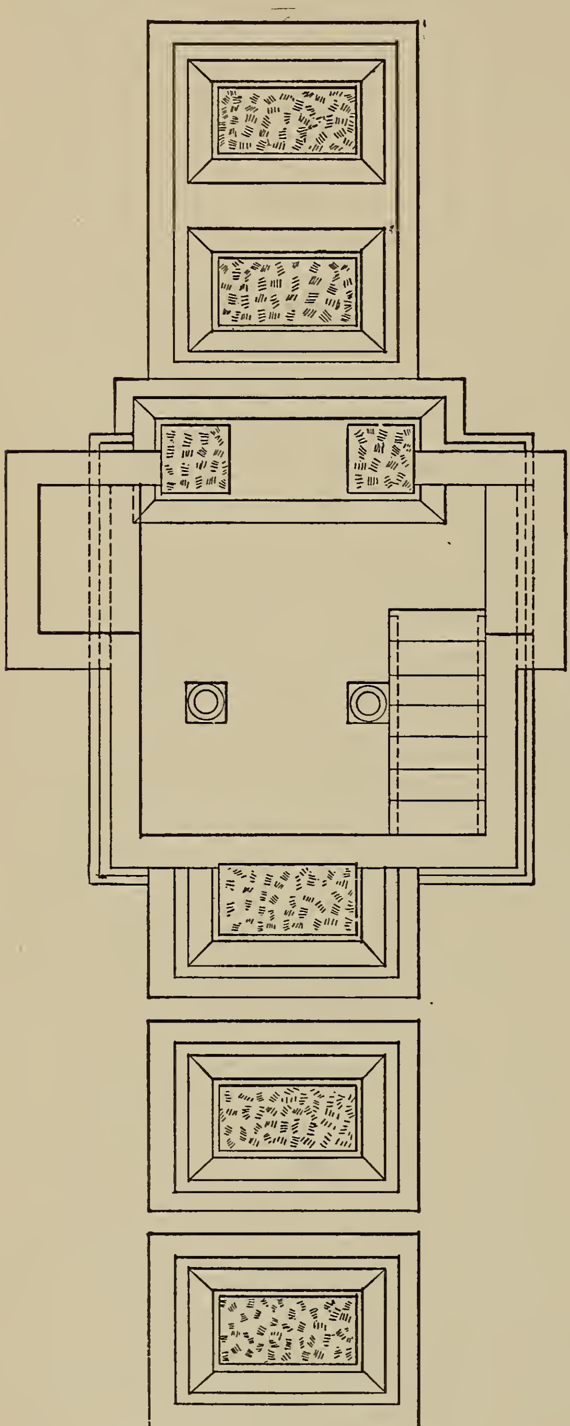


Fig. 161.—Plan of Planer Foundation.

A foundation of this kind should stand from five to ten days, according to its depth, after it is built, before the planer is placed upon it, in order that all mortar joints may be thoroughly set and perfectly hard and firm. The planer may be leveled up by steel wedges, lifting it about one quarter of an inch from the stone caps. The space around the resting places of the bed may then be closed with putty and melted lead poured in to give it a solid bed on which to rest, after which the steel wedges may be removed, leaving the weight upon the lead only. Melted brimstone is sometimes used, but its liability to crack from sudden jars renders it inferior to lead for this purpose.

In leveling up a planer, it is frequently the practice to level across the flat surfaces each side of the V's, or, if the table has been planed off when the planer was prepared for inspection in the shops, to place the level on that. The best plan, however, is to level up the bed before the table is put on. To do this properly, turn up three round pieces of steel whose diameter is such that as they lay in the V's of the bed they will project a half inch above its sides, and of a length equal to twice their diameter. These should be accurately ground to exactly the same diameter. (They may be made all in one piece and after-

wards cut up if preferred.) Place them in the shaper and plane a flat place one half to three quarters of an inch wide on one side of each of them, and be sure that they caliper exactly the same across from the round surface to the flat space. Place one of these in each V, at one end of the bed, with the flat surface up. Lay on the parallel straight-edge and then the level, and bring the bed up to it. The third piece is then placed in one of the V's, the length of the straight-edge away from one of those already located.

Now, level lengthwise. Transfer one of the other pieces to the V opposite the last one located and level crosswise again. Then from the last two level lengthwise, and so on the entire length of the bed. It may be necessary to go over the bed several times, never less than three times, but by this means a long bed may be leveled correctly and "out of wind." The time spent in accurately leveling up and setting a planer bed will be well spent when it comes to doing accurate work, and so saving many dollars in the usual expense of scraping work to fit on account of poor planing.

To have a planer so set up as to do really first-class work will save from 40 to 60 per cent of the usual scraping expenses, due to even fair work, besides the satisfaction of having a machine whose work can be depended upon.

The general principles here laid down should be followed in building the foundations for all classes of machine tools requiring a substantial foundation. And it should be remembered that in building such foundations they must be, first, of sufficient weight of material in proportion to the weight of the machine to be placed upon them to be able to withstand successfully all shocks and jars without injury, as well as to be capable of sustaining the weight of the machine without undue settling so as to throw the machine out of level or out of line in any part. And second, that the excavation is down to solid ground, certainly that all "made ground" or artificial filling is taken out; and that if the earth is still yielding, artificial support must be obtained as described in Part First for the foundations of buildings.

PART THIRD

MACHINE SHOP MANAGEMENT

CHAPTER XXV

MACHINE SHOP MANAGEMENT

Modern methods. Divided responsibilities. The "shop tree." The three grand factors. Capitalization. Manufacturing. Selling. Graphic diagram of the organization of a manufacturing establishment. The regular channel for orders and reports. Relations of the departments. The secret of success in management. The value of individuality. Indiscriminate criticism harmful. Frenzied mechanics. The quiet and methodical manager. Some prime facts concerning systems. Any reasonable system better than none at all. Patchwork systems. The successful system. A system to be effective must be carried out as planned. A good system requires a strong manager. Vacillation of management disastrous. Plan of organization. Efficiency the first requisite. The management. The United States Army system. A criticism. The military idea in the shop. Analogous positions and duties. The superintendent's functions. The assistant superintendents and their duties. The foreman and his work. The "gang boss" and his value in the shop.

There is no truer illustration of the saying that "old things have passed away and all things have become new," than is shown by the modern methods of the management of the manufacturing enterprises of the present day. The days of the "one-man management" have passed away, and in their stead has come the management by a system of divided and properly distributed responsibility, whereby the real head of the establishment takes up only the consideration of the larger, broader, and more comprehensive questions of importance in management, leaving to his able assistants the questions of the next grade of importance, and in their special spheres, while they, in turn, divide the next grade of lesser responsibilities with *their* assistants, the foremen, and so on down through the several grades of less importance to the operatives or workmen.

Thus we have what has come to be known as "the shop tree," representing graphically this plan for the division of responsibility in the management of the entire plant.

There are three grand factors that go to make up the sum of this problem of manufacturing which should not be lost sight of at the outset. The first is the capitalization of the scheme; the second the manufacture of the product; and the third, the marketing or selling of the product.

The first factor comprises the stockholders, represented by the Board of

Directors, whose head is the president of the company, and whose executive officer is the general manager. This group includes the administrative and financial departments of the entire establishment.

The second factor comprises the manufacturing plant, whose head is the works manager or superintendent, and includes the purchase of stock and supplies, the care of the grounds and buildings, and the entire process of manufacturing and shipping the product.

The third factor includes the advertising or publicity department, and the sales department, each with its own manager, and frequently presided over by the vice-president.

While each of these departments are of prime importance in all respects, it is the second that particularly concerns us in this work. Nevertheless it may be interesting and instructive to present, in Fig. 162, a graphic diagram representing the division of duties and responsibilities as generally arranged for establishments such as we are considering, and as representing the management of our model manufacturing plant.

This will show the regular channel for all official orders and communications, as well as, inversely, the channel through which all reports go through intermediate officers to their proper and ultimate destination. It also shows the proper relation of one department with another, of certain groups of departments with other groups, and in a general way the entire plan of organization and management. A careful study of these important relations is recommended to the earnest student of machine shop and factory organization, management, and economics.

Now a few words of practical common sense on the subject of the successful management of men from the standpoint of personal experience and observation during years of actual shop work and supervision.

If we search diligently and conscientiously for the secret of success in management, whatever may be the importance of the responsibilities, from the president down to the "gang boss," we shall find that it lies principally in the ability of the manager to find the right man "who can do things," and then let him alone so as to give him an opportunity to accomplish the duty devolving upon him. It often requires less talent and genius, not to say common sense and good judgment, to find the man to "carry the message to Garcia," than to keep your hands off and let him do it in his own way.

Again, the business may have reached the limit of its expansion under a certain man because the man isn't big enough or broad-minded enough to let his subordinates "do things." He is forever interfering with the routine and methods of his manager, and every one else, for that matter, and so individuality is lost, efficiency lowered, and the value of the man and the force greatly impaired. Thus the effort is made "to please the old man" rather than to

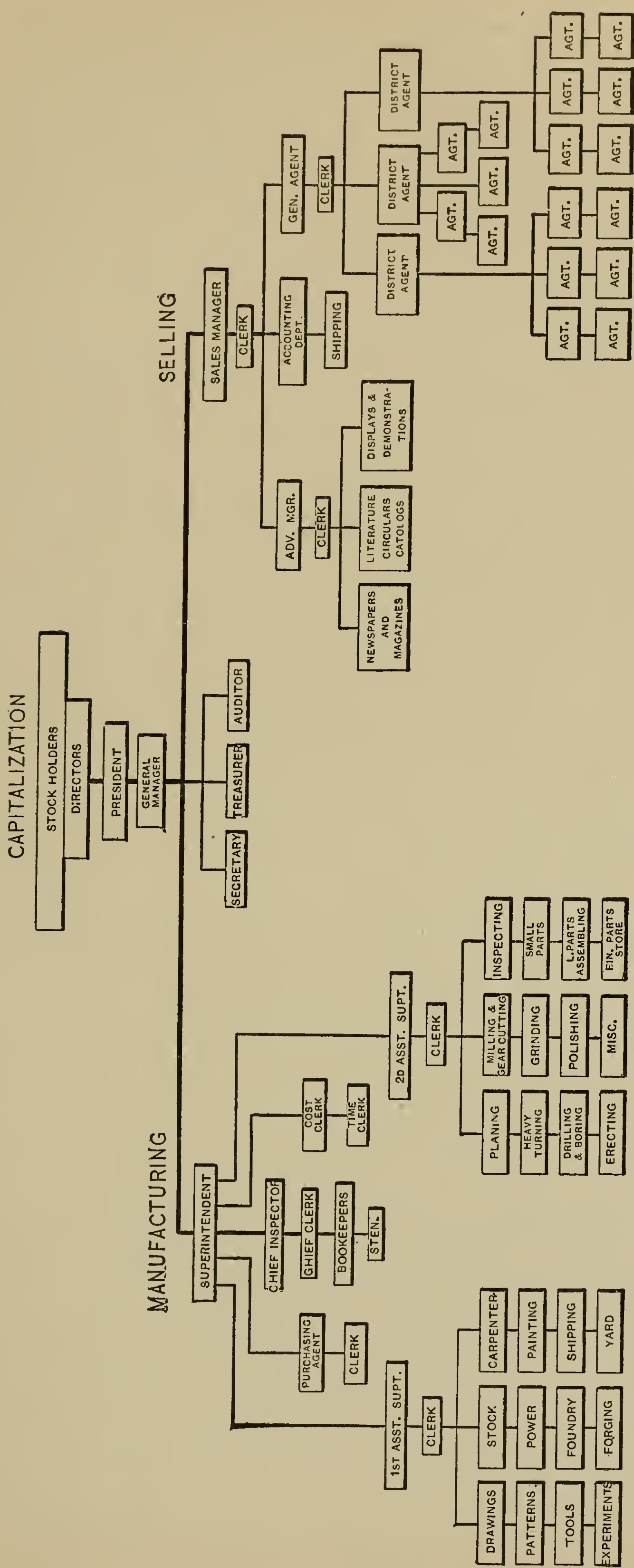


FIG. 162. — A Graphic Chart, showing the System of Organization and Management of the Modern American Shop or Manufacturing Plant.

improve the management, the condition, and the conduct of the business. Good ideas of experienced men are smothered by objections, the results "damned by faint praise," or "tinkered" until their identity and usefulness is entirely lost and their author discouraged in making others in the future.

Another equally reprehensible and quite as disastrous propensity is for "the old man" to make periodical raids through the establishment, grumbling and criticising right and left "without just cause or provocation," after the manner of the proverbial "bull in the china shop," and with equally unpleasant results to the employees and to the business.

While we are ready to admit with a somewhat prominent writer that there is a good deal of "frenzied finance" abroad in the land, we have not far to go to find equally prominent instances of frenzied mechanics, in which there is much more noise than good sense, good judgment, or knowledge of human nature, as represented by the large majority of employees in machine shops and manufacturing establishments generally.

The best and most successful managers are the *leaders* and not the *drivers* of men. The quiet and methodical manager naturally creates an atmosphere of loyalty and discipline among his subordinates, who obey his orders with alacrity and good faith. Hence, good results flow naturally from their united efforts, while the nervous, belligerent manager with the "billy-goat" propensity of "butting in" on any and all occasions, not only keeps "rattled" himself, and so in no condition of mind to properly decide important questions, but is an important factor in producing a state of incompetency, disorder, and consequent failure.

Let us now proceed to consider the management of a model machine shop or manufacturing plant in a general way, leaving the scheme of the different departments in detail for later consideration.

Probably no one will take exception to the proposition that we shall have reached the perfect system of management when we shall have devised methods by which we may produce the greatest amount of good work with the smallest number of employees and the least amount of friction and irritation among them.

How this is to be accomplished is worthy of the most patient investigation, for the question of the management of machine shops and manufacturing plants is one of many phases. There are several general propositions in this connection that should be briefly stated. Among them are the following:

First. Any reasonable system is better than no system at all. There are shops to-day running, or trying to run, in which there is really no system worthy of the name, and things are allowed to drift along from day to day "by guess and good luck," just as they did forty years ago, and if we inquire why this or that thing is done so and so, we get the stereotyped reply, "That's

the way we've always done it." One of these days these shops will "wake up and find themselves dead," as the Irishman said, or they will adopt some kind of a system that will be of modern brand.

Second. The adoption of a part of a system, or a system for one part of the works and not for the remainder, "just as a trial to see how it will work," is practically no better than no system at all."

Third. The endeavor to adopt a system composed of parts of various systems, grafted upon, added to, dovetailed together, and patched until they lose all their identity, like Joseph's coat of many colors, is but to invite a dismal failure. Many a good plan has been killed and its author humiliated by adopting it piecemeal.

Fourth. To be successful the system must be complete and comprehensive, clearly defining every regulation as to the progress of the work, the method of accounting for time and materials, records of pay and efficiency of employees, and the duties and limitations of authority of every person concerned, from the manager down to the errand boy, so that the fewest cases may arise that have not been provided for in the system, and that there may be as much certainty and distinctness as in the regulations of the United States Army. Then we shall realize the highest efficiency and the least amount of friction.

Fifth. The system must be carried out in every particular as it is planned, unless there are very serious reasons for a change. Of course, even the Constitution of the United States can be amended, but only for weighty reasons, and "while it stands, it goes." Shop regulations should be on the same basis, and all employees will soon come to respect them, and to realize that they operate just as much for their welfare and protection as for the benefit of the owners of the plant; that so long as they are obeyed in a spirit of faithful service the employee is always right; and that when they are disobeyed through carelessness, a desire to shirk duty, or even from the "smart Aleck" notion that some employees get into their heads, there is a good prospect for trouble to the offending parties.

Sixth. The man who is to manage the administration of the system must be strong, able, honest, fearless, and positive. He must be strong in carrying out the system that has been adopted; otherwise his weakness will be soon discovered by his subordinates and the "backbone" of the system will be broken. He must be able, both by education and experience, to understand and appreciate all the details of the business. Of course, he must be honest in all his dealings with his subordinates as well as with the owners. He must be fearless, giving his orders where and when and to whom they are necessary and take the responsibility for their effect when faithfully obeyed. Hesitation, vacillation, or indecision will very materially injure his authority. To give an order and, when it has been obeyed faithfully and failed of the

object sought, to blame those who executed it, is to cause his men to lose faith, not only in his ability but in his sincerity. And there is only one thing more damaging to the administration in the minds of the employees than this, and that is to show a lack of faith in their ability and honesty. This will always prove discouraging and cause the men to lose interest in the successful progress of the shop.

Such being the general conditions under which we must organize, we may proceed with the further consideration of the system by which our plant is to be managed. We must first know what we are to plan for. It is assumed that the plant and all its accessories have been designed and equipped for manufacturing only. Therefore, with the exception of the shipping facilities, the entire establishment is devoted to turning out and shipping what it is directed to make. To accomplish the results we seek, we must go about the matter with a definite and comprehensive plan. It will not do simply to decide some of the main features and leave the others to be determined as we go along. If we do so we shall probably be surprised to find that some of the minor matters will loom up as important features when we least expect trouble.

We will consider the scheme of organization. In deciding what plan is best we should look to efficiency as the first requisite. This will include the question of making the most of the services of each man in a responsible position; it will include the consideration of a plan that shall have the least friction between the different officials in the routine work of the shop. It will seek a proper division of responsibility, so that if anything goes wrong we may at once determine what man was responsible for the lack of attention to duty. It should be a plan that will produce a maximum of result with a minimum of effort. Every man must know exactly what his duties are, what are the limits of his authority, as well as from whom he takes and to whom he may give orders.

It will be understood, of course, that the entire management of the plant is under the charge of the superintendent and that all orders from the general office go to him direct, and that there is no interference with any other official of the shops by the general manager or any one in the general office. This sort of interference "over the head" of the superintendent will break up the discipline of any shop, and it should never be indulged in by the authorities in the office or permitted by the superintendent. It should be the same with all officials in the shop. No official or employee should accept any order unless coming to him in the regular way through the next higher authority.

We think it has never been seriously questioned, that the organization of the United States Army, with its division of responsibilities, the provisions for accounting for all property handled, and for ascertaining the final results, as

well as for keeping a definite record of the individual efficiency of both officers and men, is a well-nigh perfect system. Its practical utility is not thoroughly appreciated by the manufacturers of to-day, who are prone to look upon anything labeled "military" as savoring of arbitrary and summary methods that in the shop would be disagreeable to both employer and employee. That this is too apt to be the popular impression is evident from the remarks of a recent writer on this subject, who says:

"Under the military type of organization the foreman is held responsible for the successful running of the entire shop. He must lay out the work for the whole shop, see that each piece of work goes in the proper order to the right machine, and that the man at the machine knows just what is to be done and how he is to do it. He must see that the work is not slighted, and that it is done fast, and all the while he must look ahead a month or so either to provide more men to do the work or more work for the men to do. He must constantly discipline the men and readjust their wages, beside fixing piece work prices and supervising the timekeeping."

This is hardly a fair conception of what military rules mean, as it is surely anything but military. No military officer has any such variety of duties to perform. As well might it be contended that the colonel of a regiment takes command of the police guard or drills the awkward squad, or that a captain teaches the recruits the manual of arms. On the contrary, the colonel commands a regiment, but he gives orders to his majors who command battalions and give orders to the captains of companies. They in turn give orders to the non-commissioned officers who instruct the enlisted men. Each officer has his clearly defined duties, authority, and limitations. It is true that the organization and management of many of the larger and more successful manufacturing companies in this country to-day are using systems very closely modeled after the military methods, and in many cases, as investigation will show, following the army methods much more closely than is realized by many men.

Let us consider for a moment the analogy which may exist between a regiment of infantry and a large machine shop plant, with its force of officials and employees. The general manager may be likened to the general in command, and the machine shop or manufacturing plant to a part of an army, say a regiment of infantry on active service. The colonel in command will be represented by the superintendent or works manager. The colonel must have a staff, each of the officers composing it being at the head of one of the staff departments. So here we must have a staff, and it will consist of the office force, and include the chief clerk, purchasing clerk, time clerk, cost clerk, and the stenographer, all reporting directly to the superintendent.

A regiment is divided into two or three battalions commanded by majors.

Our force will be divided into two parts, each under an assistant superintendent. Each battalion is composed of a number of companies, commanded by captains. Our two groups are divided into certain analogous departments each in charge of a foreman. Our arrangement will be for the first assistant superintendent to have charge of the drawing room, pattern shop, tool room, experimental room, stock room, power house, iron foundry, forge shop, carpenter shop, paint shop, shipping room, and the yard gang.

The second assistant superintendent will have under his charge all of the strictly machine shop departments, consisting of the planing department, heavy turning department, drilling and boring department, milling and gear-cutting department, small parts department, grinding department, polishing department, finished parts storeroom, small parts assembling department, erecting department, and inspecting department.

This, then, is the skeleton of the plan of our organization and from this we may make up what is called, in army parlance, the roster. This will include all responsible officials, commencing with the superintendent and the office force, then the assistant superintendents, foremen, etc. A little further on we will add others more intimately connected with the workmen.

This plan requires the superintendent to look after his office force as to accounting, purchasing, issuing, time keeping, pay roll, manufacturing costs, and the correspondence, and to hold the two assistant superintendents responsible for all of the requirements of their respective jurisdictions. In a plant of the capacity which we have been considering and the force employed this will be all that one man can be expected to do.

In the same manner the two assistants will find their time quite steadily employed in the successful management of the eleven or twelve departments in their charge. The assistant superintendents should be men of good executive ability, good machinists, and understand in detail the operations of machining and working every variety of work or material handled under their supervision. They should understand drawings thoroughly and be able to make any of the calculations usually made in the drawing room. They should understand the character of the men under their control and the characteristics of machinists or other tradesmen working under them.

While these men are officials capable of handling men by direct contact with them, their positions now place them one step beyond that, and all matters of instruction as to the work, the everyday routine in passing work from one department to another, the discipline of the force under their charge, should be done with the foremen, and never with the men.

An infallible rule for injuring the efficiency of a shop official of whatever rank is for some higher authority to ignore him and pass orders on to the grade below him, or, in shop parlance, to "make a bridge of his nose." The

foremen, in turn, give the work to the gang boss having charge of similar work, and he instructs the workmen when necessary and sees that the work is pushed along. This may seem a little like "red tape," but it is at once the quickest, surest, and safest way to manage the shop, and one that will produce the greatest amount of good work with the least friction and ill-feeling on the part of the employees. Still, any official witnessing a violation of the sanitary or of what may be called the police regulations of the establishment is expected to call the offender to account and later to report him to his foreman.

The foreman should be a man of excellent mechanical ability, understand drawings thoroughly, and be able to make any of the ordinary calculations necessary. He should be able to make estimates as to time, cost, and material, of anything handled in his department. He should know the characteristics of men in general and the abilities and dispositions of those under his control. If his room is large enough to have gang bosses he should give his orders to them, and not to individual workmen. He should know every item of work passing through his room, keep things moving in it, and see that work transferred to him from another department is in proper condition and is promptly used, and that the product of his department going to another one is in proper condition for the transfer and is passed on without unnecessary delay.

It is not at all necessary that the foreman of a small department, or over a few men, should devote all or even a large percentage of his time to strictly foreman's duties, as he may be able to do considerable work himself while directing others. The point is, to have one competent man in charge of the force, the gang, the room, or the department, whom we can hold responsible for the results in that department. In the same way some departments may be large enough to require gang bosses, or assistant foremen.

The gang bosses or foremen of small departments may do some machine work themselves, but it frequently happens that it pays better when they do not, but on the contrary give their entire time and energy to keeping things moving; to seeing that the operatives at the machines are supplied with proper tools and materials, that their product is promptly moved out of their way when completed, and that everything moves harmoniously, with proper speeds and feeds on all the machines. The gang boss may thus make himself a very useful man.

There is another view of the question. The gang boss is very likely to be more in the position of "one of the gang" than the foreman, more closely affiliated with the workmen of his gang than a foreman is ever likely to become, and the men will naturally feel more interest in their work under his direct leadership because of this.

In our analogy of the plan of organizing and administering the affairs of a manufacturing plant to the military organization, we had got to the foreman

as corresponding to the captain. Our gang bosses will fittingly represent the non-commissioned officers. These are privates of more than ordinary ability and faithfulness and have been promoted for these reasons. They are the real leaders as well as instructors of the privates and form what might be termed the connecting link between them, as a class, and the commissioned officers. So should the gang boss or assistant foreman be, and his influence for good in the smooth running and harmonious, as well as efficient and profitable, conduct of the shop is a very important matter which should receive the most careful consideration in the organization and operation of the plant.

The gang boss should be a man properly qualified for the position; able to read drawings readily; to know enough of human nature to "size up" the abilities of the men under him, and to know, not only each man's practical knowledge of the business, but his natural disposition, so as to be able to direct him intelligently and for the best good of the establishment. In the foregoing remarks as to foremen, etc., those of the machine shop proper have been meant. But in a general way the principles are equally applicable to those of other departments.

CHAPTER XXVI

THE SUPERINTENDENT'S OFFICE

Avoiding complexity of books, forms, etc. Arrangement of the superintendent's office. Progress of orders board. Its description and use. Handling correspondence. Superintendent's orders. Assistant superintendent's orders, or shop orders. Foreman's orders. The regular routine. Orders from the general manager. The usual practice in making out orders. Routine of orders. List of parts. List of gray iron castings. List of forgings. List of purchased parts and stock. Requisition for gray iron castings. Requisition for forgings. Requisition for materials. Requisition for purchased parts. Material and cost card. Time account. Accounting for labor. Time registering clocks. "Day time." "Job time." Distribution of time. Accounting for jobs continued and jobs completed. Checking the time account. Defective material and spoiled work. Special requisition necessary. Consumable stock, materials, tools, and supplies. The supply requisition. Fuel account. Few special books required. The "loose leaf" system.

In continuing the subject of machine shop management the endeavor will be to avoid as much as possible the modern tendency toward multiplication of account books, blanks, cards, and the like. In practice we are liable to burden ourselves with such a complexity of these things as finally to build up a system costing more for maintenance than it is worth, and what is of vastly more consequence, producing results that are far from showing a correct statement of the conditions. The author has in mind a recent instance of a shop containing less than seventy employees, while the office, stock, and shipping rooms contained over twenty employees operating an elaborate system, by which a small steel part produced by less than four hours' labor was billed at eleven dollars and a job of nearly three hundred dollars earned a profit of less than fifteen dollars, according to the showing of the so-called system of cost keeping. It is such failures that throw discredit upon Cost Systems. It is true that any system of benefit must cost something, and it is equally true that any one system will not be suitable for all cases, but must be modified to suit conditions.

The offices are so arranged that the superintendent has a public and a private office. In the public office will be a large table convenient for spreading out drawings, and desks for the superintendent, the two assistant superintendents, and the chief inspector, as well as the usual filing cases, cases for

technical publications, catalogues, etc. In the large, open room of the office building is ample space and desk room for the purchasing clerk, cost clerk, and two bookkeepers or assistants should their services be necessary, and a special enclosure for the time clerk, with a convenient pay window opening into the entrance passageway.

On the wall of the superintendent's public office is fixed a board, which, by the introducing and changing of small plugs, may represent in a graphic manner the progress of the work in the shops. This board is 37 inches wide and 27 inches high, and aside from the headings, etc., is ruled in 1-inch squares by white lines on the black surface of the board. The design is shown in Fig. 163. In the center of each square is a $\frac{3}{8}$-inch hole. At the left are lettered the headings similar to those given. At the right are formed pockets in which may be placed small cards giving the months. These are used where orders run from one month into another and so on. Over the squares are figures for days of the month. Fitted to the holes is a series of wood or metal plugs, upon the $\frac{3}{8}$-inch circular face of which may be gummed discs of white paper bearing the numbers of the orders in the works. These plugs are moved daily from one hole to another as the work advances. Should it be desirable to leave a continuous record of the day of the month on which an order arrived at each stage of progress, or passed through a certain department, there should be four or more columns of holes for each day of the month, and a sufficient number of plugs with the order number indicated upon them to leave in the several holes as the work advances.

The board shown is intended for regular orders for lots of machines or of assembled portions of them carried along together. A similar board may be used for tracing the progress of job or experimental orders. It will be the duty of the cost clerk to make regular daily rounds of the shops, preferably early in the forenoon, and note down in a small book carried for that purpose the facts necessary to make the changes on the board, and on his return to the office to change the plugs to represent the progress of the work. The author saw this plan used in a plant that included a number of buildings, some of them at quite a distance from the superintendent's office, and realized what a saving of time and annoyance it was and how many necessary questions it answered during the day.

The correspondence of the superintendent's office will usually be of a limited nature and relate chiefly to quotations and purchase of materials. Letters of the purchasing clerk will be signed by the superintendent. All correspondence with the general office will be by the superintendent, although he may refer such parts as he desires to heads of departments, through the assistant superintendent having charge of them.

Matters in reference to work done in and about the plant by outside

parties should be arranged by correspondence, the nature of the work clearly specified, and if practicable a price should be fixed by the parties doing the work, and provision made for any extra work that may be found necessary. No contract for this class of work exceeding fifty dollars should be valid until approved by the general office.

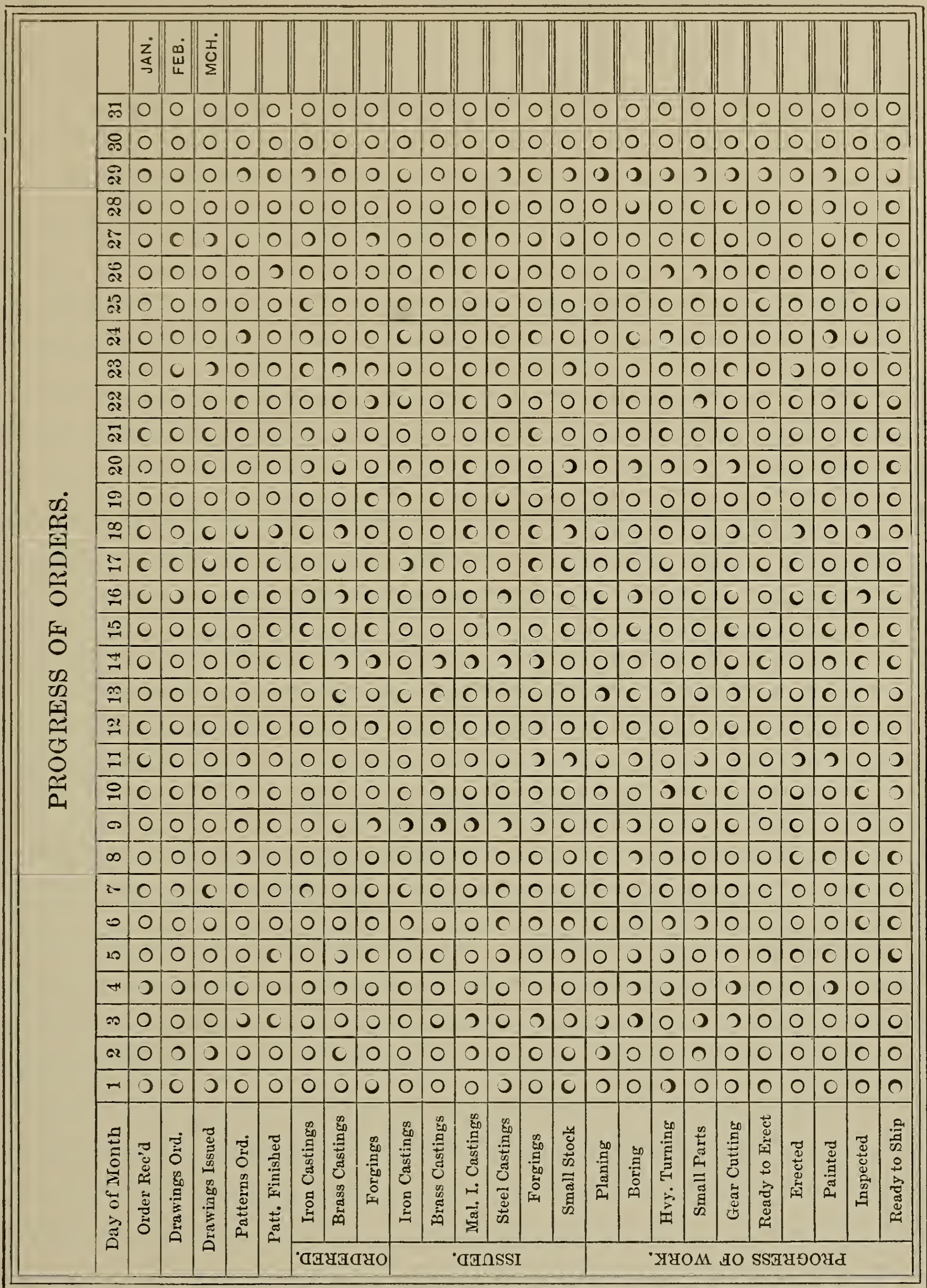


Fig. 163.— The Progress of Orders Board.

All matters that can be conveniently typewritten should be done in that manner. The practice of taking letterpress copies of letters and other matter sent out is clumsy and involves too much subsequent labor. Replies to letters

should be duplicated by carbon copies attached to the answered letter and filed by the simple and efficient vertical system.

The superintendent's orders to the shop will be made in triplicate when the work is done under the jurisdiction of both assistant superintendents, each having a copy. These should be written in a carbon copy book with an indelible pencil. This book should be $5\frac{1}{2}$ in. x $8\frac{1}{2}$ in., of white paper, and have the proper leaves perforated for removal. Each leaf has a printed heading containing the name of the firm or company, the words "Superintendent's Order," a date line, and numbered consecutively in triplicate. These orders as given will contain the order number of the general office, and those made by the superintendent for small jobs to be made from drawings should specify drawing numbers for identification, and the general office numbers if ordered from that source.

Orders to the shop which affect the entire force, such for instance as a change in the hours of work, for shutting down the works for repairs or holidays and similar matters, will be a separate series, typewritten, and carbon copies made for posting near the time clocks. They will be consecutively numbered and denominated "General Orders." The assistant superintendents will use carbon copy books similar to that used by the superintendent, but of pink paper, for their orders to the foremen. These orders should have the name of the company and the heading "Shop Orders, First Division," and "Shop Orders, Second Division," according to whether they are to be used by the first or second assistant superintendent. A date line should be added, with sufficient space for the usual rubber stamp. Each assistant superintendent will carry one of these books with him so as to be prepared to write an order at any time or place necessary.

The foremen should have similar books, 4 in. x 6 in. in size, and of light blue paper, headed with the name of the company, the words "Foreman's Order......Dep't.," and date line. Whenever drawings do not sufficiently explain the work to the workman, or in the absence of drawings, the foreman will invariably make a written rather than give a verbal order. This order is retained by the workman as his authority for the work in case there may follow any question in relation to its correctness. And this idea will be followed all the way through, not endeavoring to remember things that are proper subjects for record, not burdening the mind with dates, sizes, amounts, etc., but recording them, writing them down, stamping a name and a date upon them, and placing them on file where they may be conveniently referred to in case any question arises. The carbon copy books may be conveniently used for sketches as well as written matter, and often with more comprehensive meaning. A good sketch with dimensions can scarcely ever be made to mean what was not intended. Sometimes writing is weak in this respect, particularly if carelessly done.

The superintendent, assistants, foremen, clerks, and all others requiring use of name, date, approval, receipt, and similar matters should be provided with rubber stamps. They should date every blank, sketch, or memorandum that passes through their hands unless it already bears a stamp of even date, and it will be safer to do so then, the name being stamped as well as the date.

The regular routine method of passing orders through the works, and the books and blanks necessary for carrying out these methods, will be as follows, it being understood that many of the smaller parts of the machines being manufactured are made in large numbers and turned into the finished parts storeroom, from which they are drawn on proper requisitions when needed for assembling.

Orders are supposed to be given by the general manager for complete machines, usually in lots of varying numbers according to the size of the machines and the requirements of the market. The superintendent's orders will ordinarily be for groups of parts. For instance, in building lathes the general manager orders a lot of 25 lathes of 24-inch swing. The superintendent makes orders for 25 head stocks, tail stocks, carriages with rests, aprons, etc., complete. Then for 25 beds complete and of different lengths as specified by the general office order, and later on orders the lot, or certain parts of it, as may be necessary, to be erected and made ready for final inspection.

Copies of the superintendent's order will be given to each of his assistants. The first assistant will make his order to the drawing room, pattern shop, stock room, foundry, and forge shop, and will see that the necessary drawings go to the second assistant; that the patterns go to the foundry; that material is furnished on the foremen's requisitions; that the foundry makes the castings and that the forge shop gets out the forgings. Small castings and forgings may already be complete in the finished parts storeroom ready for use in assembling. Malleable iron, steel, brass, and bronze castings are considered as purchased stock or material if the establishment is not equipped for making them. In consequence, the purchasing clerk will order them, receiving the proper patterns from the pattern shop. The storekeeper will receive and receipt to the purchasing clerk and issue them to the proper departments with an invoice of their numbers, weights, cost, etc. The information for making the orders for stock, materials, and purchased parts is derived from the drawing room which furnishes lists of parts (see Fig. 164) of the different machines as well as of the different kinds of material used in their manufacture. These lists are on white paper $5\frac{1}{2}$ in. x $8\frac{1}{2}$ in. As many sheets are used as may be necessary and fastened together with the staple binder. There should be a sufficient number of copies made to supply one copy to the superintendent, each assistant and each foreman doing work on the parts and requiring them, as well as to others as the superintendent may require. Those going to the foremen may

have unnecessary sheets omitted. For instance, the foreman of forge shop will not want a list of castings, etc.

The list of gray iron castings shown in Fig. 165 is followed by that for malleable iron, steel, brass, and bronze castings, and these by the list of forgings (see Fig. 166), specifying materials, and lastly by the list of purchased parts and materials. As these lists are quite similar for the several machines, as

Name of Company.

LIST OF PARTS

for ------------------------------------

Date --------------

Part No.	Name	Material	For each Machine

FIG. 164.—Size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, White.

Name of Company.

LIST OF GREY IRON CASTINGS

for ------------------------------------

Date ------------

Part No.	Name	For each Machine	Weight

FIG. 165.—Size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, White.

for instance, a series of lathes differing principally in the size, the matter may be nearly all printed. Materials from which forgings are to be made may be briefly marked thus: WI wrought iron, CS cast steel, TS tool steel, etc.

The blank shown in Fig. 167 will include bolts, nuts, washers, cap, gib and set screws, sheet brass and steel, brass tube, square and round cold rolled or drawn machine steel, tool steel, and similar stock.

Name of Company.

LIST OF FORGINGS

for ------------------------------------

Date --------------

Part No.	Name	For each Machine	Material	Weight

FIG. 166.—Size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, White.

Name of Company.

LIST OF PURCHASED PARTS AND STOCK

for ------------------------------------

------------ Date ------------

Part No.	Name	For each Machine	Weight

FIG. 167.—Size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, White.

The first assistant superintendent will have made out the order to the foreman of the foundry for gray iron castings on the form in Fig. 168. The blank is perforated down the center. The right-hand portion is torn off and sent to the foundry. The other half is used to check the number of pieces and weights as the castings are received. Their weight will be added to the material card.

The requisition for forgings is Fig. 169. This is filled out in duplicate, the first half being retained to check receipts of forgings upon, and the second

half is sent to the foreman of the forge shop as his authority for doing the work, for which stock will habitually be stored in the forge shop, having been delivered in bulk by the storekeeper and charged. It is to be checked on forgings delivered, each lot bearing its proportion of waste according to the job and stock used. A special account of this stock is kept by the storekeeper, charging additions and crediting with forgings turned out.

NAME OF COMPANY					NAME OF COMPANY.			
GREY IRON CASTINGS					GREY IRON CASTING			
REQUIRED FOR ______					FURNISHED FOR ______			
ORDER NO. ______ DATE ______					ORDER NO. ______ DATE ______			
PART NO.	NAME	NUMBER WANTED	NUMBER REC'D	WEIGHT	PATTERN NO.	NAME	NUMBER WANTED	NUMBER DELIV'R'D

FIG. 168.—Size, 8½ x 11 in. Color, Grey.

The requisition for materials is Fig. 170. This is filled out in duplicate and sent entire to the storekeeper, who retains the first half and sends the second half with the materials, where they are ordered by a note at the bottom of the first half. He fills in the costs for the guidance of the foreman to which it is sent.

The requisition for purchased parts, parts that are purchased in a finished or nearly finished condition for use, is Fig. 171.

Before the job starts in the shop a stout card is prepared to receive the costs of material and labor expended upon it. The front of this card is shown in Fig. 172. The card has a list of the usual materials given in one column, while the other is left blank for the other articles used. The weights, number of pieces, and the cost, as shown by the storekeeper's invoice received with the articles, is also written in by the foremen. The back of card shows an account of the time spent on the job as provided for in Fig. 173.

Name of Company.							Name of Company.			
FORGINGS							FORGINGS			
Required for ______							Furnished for ______			
Order No. ______ Date ______							Order No. ______ Date ______			
Part No.	Name	Material	Number Wanted	Number Rec'd	Weight	Part No.	Name	Material	Number Wanted	Number Rec'd

FIG. 169.—Size, 8½ x 11 in. Color, Light Blue. (The last column at right should be "number delivered.")

This time account the foreman obtains from the employees' job cards, registered in the time clock as hereafter described. This material and cost card will go with the work from one department to another, receiving its additions of material and labor account as it passes along, and furnishing, when the job is completed, a correct material and labor account of the work, and is turned in to the cost clerk.

These blanks are made of different colors to assist in their ready identification, as it is well known that colors appeal to the sight much more quickly than does the printed heading. The colors of the different blanks are so arranged

that similar colors do not appear in the same department for different purposes. The blanks are arranged to suit regular printer's sizes of paper, which is usually 17 in. x 22 in., and cardboard, which is 22 in. x 28 in. It is not necessary or advisable that all blanks shall be of a uniform size, although there should be no more different sizes than necessity or convenience demands. They may be ruled horizontally for convenience in writing if desired, but many prefer them plain, particularly in the smaller sizes.

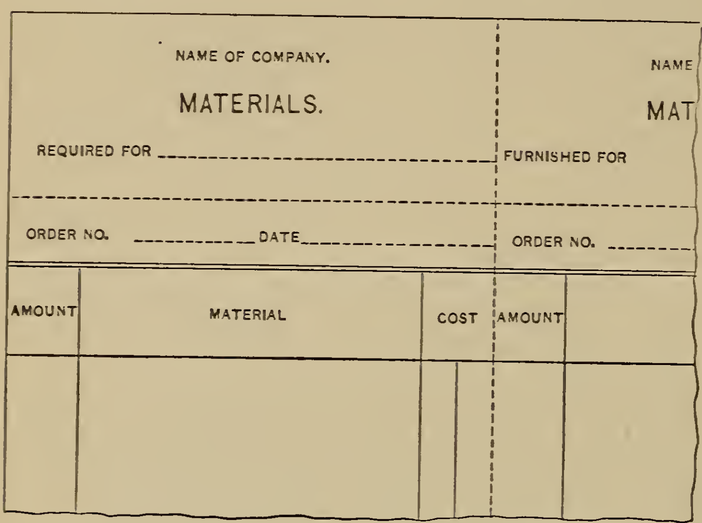

NAME OF COMPANY.
MATERIALS.
REQUIRED FOR
FURNISHED FOR
ORDER NO. DATE
ORDER NO.
AMOUNT | MATERIAL | COST | AMOUNT
NAME
MAT

FIG. 170. — Size, $8\frac{1}{2}$ x 11 in. Color, Light Green.

It is now proper to describe the method by which labor is accounted for. There is in vogue in the different shops of the country many and various styles and forms of time cards for recording the time of employees on different jobs of work or on different operations on pieces of the same job. A large majority of these require the employee to do some writing upon them. This is disagreeable to the men and frequently not correct. It is difficult to tell why a man does not want to make out a time card, but every shop man knows the fact well enough, and all have heard men growl about it and say, "I'm a machinist, not a bookkeeper or a clerk," and if they don't swear aloud they are apt to think it, and that injures their efficiency just as much. Various registering clocks have been devised to remedy these difficulties and to a greater or less degree they have helped matters quite a good deal. One of the most practical of these is that called the International Card Recorder. In this clock a card is dropped into a receptacle, a lever depressed and as a bell rings the actual time to the minute is printed on the time card in a space allotted to it. The changes from A. M. to P. M. as well as that from day to day are performed automatically by the clock mechanism. A lever operated by the workman changes the position

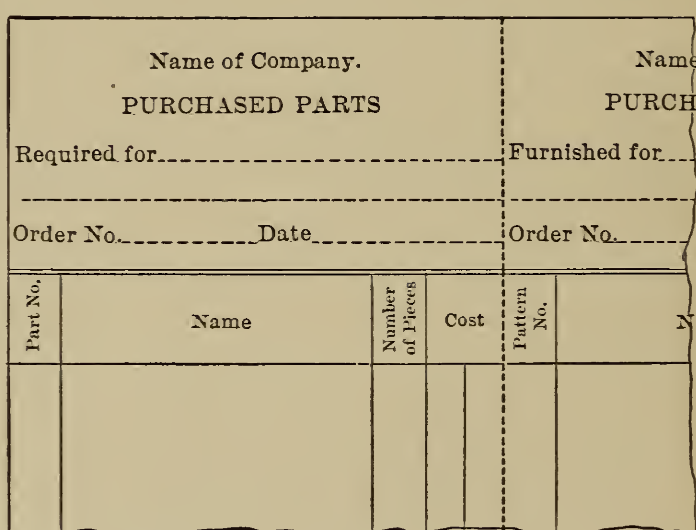

Name of Company.
PURCHASED PARTS
Required for
Furnished for
Order No. Date
Order No.
Part No. | Name | Number of Pieces | Cost | Pattern No.
Name
PURCH

FIG. 171. — Size, $8\frac{1}{2}$ x 11 in. Color, Yellow.

of the card from "in" to "out" according as the man is beginning or quitting work. The cards are of sufficient length to contain a week's record, and special spaces are provided for overtime. They are made out by the timekeeper and placed in the "out" rack on Saturday after the men have quit work. They have the workman's name and number at the top and are kept in a special rack or case at the side of the clock from which the workmen approach it, so that they may each take the proper card out of the case, step to the clock, stamp the hour, pass to the case on the opposite side of the clock and drop it into the case there. Over these cases are placards bearing the words "Day Time. IN." and "Day Time. OUT." One of these time cards is Fig. 174.

NAME OF COMPANY.

MATERIAL AND COST CARD.

ORDER NO. ____________ DATE ________________

STOCK	WEIGHT	COST		STOCK	PIECES	WEIGHT	COST	
C.I. CASTINGS								
MAL. "								
STEEL "								
BRASS "								
BRONZE "								
BABBITT								
MEH. STEEL								
CAST "								
TOOL "								
WT. IRON								
PATTERN LUMBER								
BOX								

FIG. 172.—Size, 5 x 7 in. Six Ply Card Board. Color, Light Red.

NAME OF COMPANY.

TIME ACCOUNT.

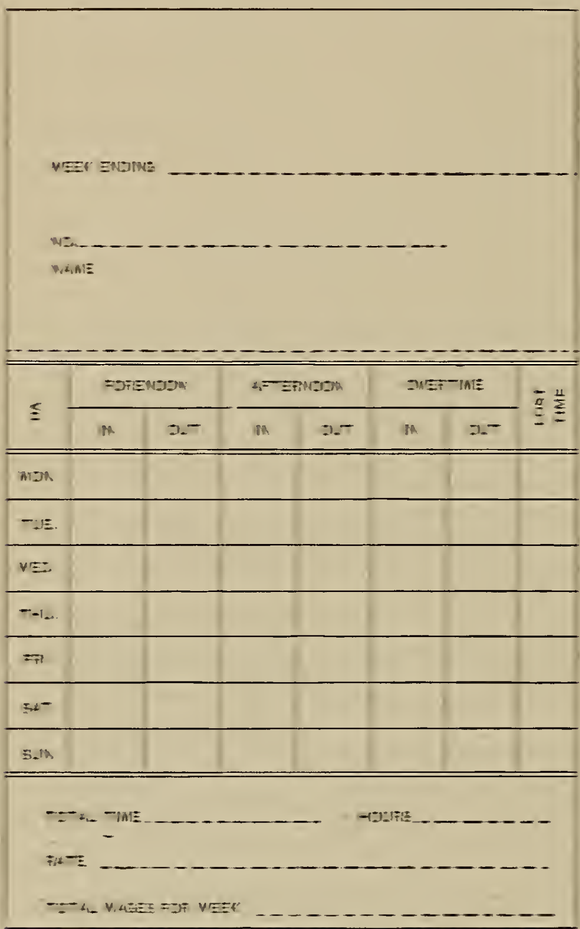
ORDER NO. ____________ COMPLETED ________________

DEPARTMENT	AMT.		DEPARTMENT	AMT.	

FIG. 173—The Time Account (on the back of the Material and Cost Card).

At the end of the week the cards are dropped into a box marked "Day Time," and placed under the "Out" case, and the timekeeper takes them up when leaving cards for the next week, and after computing the time he fills out the amount due each employee and enters it in his roll book. The time cards may be had in all colors. In this case we will use straw color for the day time cards, and for job time a different color for the employees of each department using the same clock. There should be a sufficient number of clocks to allow one clock to each hundred employees, or less, if the distance from their department renders it necessary to avoid too much loss of time in registering job time.

To ascertain the proper distribution of the time among the different classes of work, or different parts of a machine, or even the different operations on a single part, job cards are used by the workmen in addition to the day time card. They are of a distinctively different color and are made out by the foreman under whom the employee works. These cards give at the top the workman's name and number and specify the work he is engaged upon. He "rings in" this card when he begins work on a job and "rings out" when the job is completed. The foreman sees that he is supplied with a new card to "ring in" when he "rings out" the former one.



WEEK ENDING ____________

NO. ____________

NAME

DAY	FORENOON		AFTERNOON		OVERTIME		LOST TIME
	IN	OUT	IN	OUT	IN	OUT	
MON.							
TUE.							
WED.							
THU.							
FRI.							
SAT.							
SUN.							

TOTAL TIME ____________ HOURS ____________

RATE ____________

TOTAL WAGES FOR WEEK ____________

Fig. 174.—The Time Card, size, 3¾ x 7½ in. Straw Colored Card Board.

When a man is running two or more machines on different orders there are as many separate cards as there are order numbers, all "rung in" and "rung out" as if there were but one. The time clerk divides the time accordingly. If one of these machines is much larger than the other and requires much more of a man's time, as for instance, a 60-inch and a 24-inch planer, the job on the larger machine must be charged in proportion. It sometimes happens, however, that in the above case the smaller planer, if on short cuts, will consume the more time. This is a matter for the foreman to determine and advise the timekeeper. If a workman is on a job from day to day he uses the same job card, dropping it into the box marked "Job Completed" on Saturday night, and receiving a new job card Monday morning.

There might be still another box marked, "Job Continued," but the number of boxes would, perhaps, cause confusion. In our case this is avoided by the foreman's stamp, "Completed," when the job is finished. If the job is completed during the day the workman will have the foreman stamp his job card before dropping it in the box. The object of this arrangement for job cards is that the timekeeper may compute the time shown on them and ascertain if it aggregates the amount shown by the day time card by which he is paid. The job time cards are kept in racks or cases similar to those

used for the day time cards, the placards over them being lettered, "Job Time Only. IN." and "Job Time Only. OUT."

The timekeeper transfers the amounts on the job cards to the job time book, which is ruled up as in Fig. 175. This book may be used as a monthly instead of a weekly account if desired. This account of job time will be a check against the foreman's account given on the material and cost card which goes with the work through the different departments, and is finally turned in to the cost clerk, who may also compare it with the storekeeper's account of stock, material, and purchased parts issued and charged to the different departments.

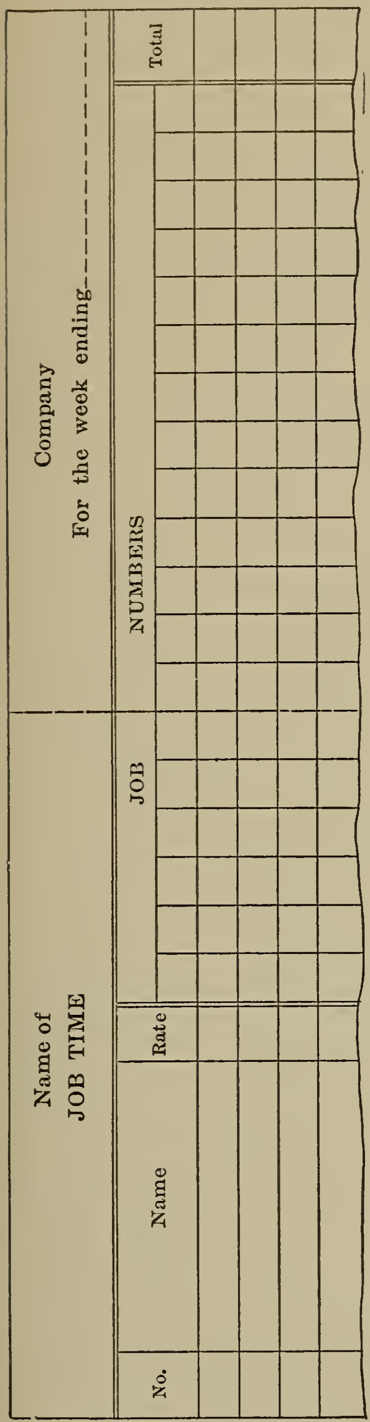


Fig. 175.—The Job Time Book, size of Book, 9 x 12 in. Folds on center line.

More or less spoiled work will turn up from time to time; some parts or articles of stock or material will be lost and cannot be accounted for; some that will be found defective; and some parts rejected by the inspector. To replace these will require separate consideration and treatment from the routine manufacture. In the case of the manufacture of small parts in quantity, to be turned into the finished parts storeroom, the count, as they go from one department to another, will be lessened as parts are spoiled or rejected and the cost per piece will be correspondingly increased. But in case a certain number of parts are required to be made on an order we must devise a means for the issue of stock and material to replace that defective, lost, spoiled or rejected, and under proper safeguards to prevent misuse. This will be by a special requisition, signed by the foreman of the department and approved by the assistant superintendent, specifying what is wanted and the reasons why it is required, that is, to replace defective material, spoiled, or rejected parts, etc. This requisition should be made in duplicate, one copy retained by the storekeeper and the other filled out with the costs and sent with the articles to the department requiring them. Fig. 176 is the form to be used.

In filling out this blank the words "Defective Material, Spoiled Material, Lost Material, and Rejected Parts," that are not needed may be erased by

drawing a line through them. These articles will be charged by the foreman on the material card and to the labor account, adding so much to the cost of the work.

We will now consider consumable stock, material, tools, and supplies and

Name of Company.
SPECIAL MATERIAL REQUISITION.
Order No.............Date,...............

The following is required by reason of DEFECTIVE, SPOILED OR LOST MATERIAL OR REJECTED PARTS, OF MACHINES.

Part No.	Material	Number Pieces	Weight	Cost	

Name
SPECIAL MATE
Order No.......

The following reason of DEF LOST MATERI PARTS OF MA

Part No.	Mater

FIG. 176.—Size, 8½ x 11 in. Color, Bright Red.

how they are to be treated. Coal for boilers, for cupolas, for forge shops; coke for foundry and forge shop; charcoal for forge shop; wood, etc., will be purchased in large quantities, as will also molding sand for foundry and

Name of Company.
FUEL ACCOUNT
of the..............................
For week ending......................

Fuel	Amount	Cost	

Name
FUEL
of the...........
For week ending

Fuel

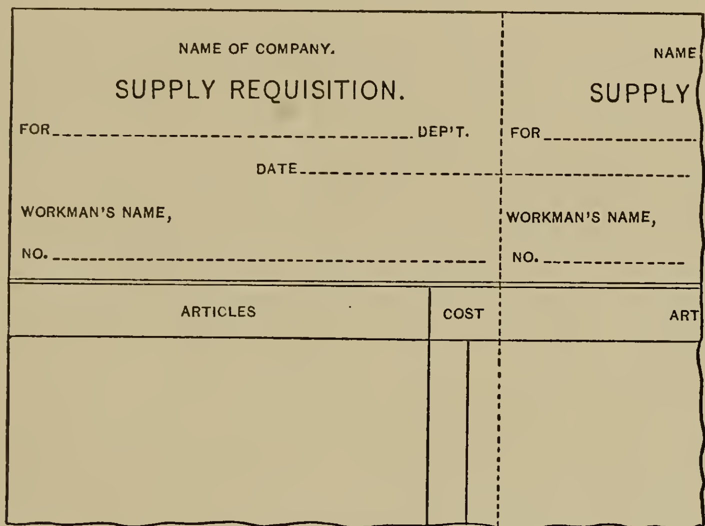
FIG. 177.—Size, 5½ x 8½ in. Color, Chocolate.

stored for use. Returns of amounts used will be made to the cost clerk weekly. This return for fuel is shown in Fig. 177. The weekly return for molding sand, etc., will be a similar form. These are filled out in duplicate, one part being retained by the department from which it comes.

Consumable stock, materials, and tools for the different departments are drawn on requisitions made in duplicate, one part retained by the storekeeper and the other returned with the articles as an invoice, by which method each

foreman may know the expense in his department for these articles, as well as the expense of each of his men in this respect. By consumable articles is meant, of course, waste, oil, files, brushes, emery and emery cloth, and all similar articles issued by the storekeeper and consumed or worn out in the shop. Fig. 178 is the blank to be used. These requisitions will not be sent to the storeroom by the workmen, but by an errand boy, who may profitably be employed in one large or two or three small departments.

It will have been noticed that little has been said in this chapter as to the form of books to be used. The reason is that with the exception of such as have been described, they are the ordinary ones that need no special mention, and the proper ones will readily suggest themselves. The manufacturers of


NAME OF COMPANY.
SUPPLY REQUISITION.
FOR ________ DEP'T.
DATE ________
WORKMAN'S NAME,
NO. ________
ARTICLES | COST

NAME
SUPPLY
FOR ________
WORKMAN'S NAME,
NO. ________
ART

FIG. 178.—Size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, Manila.

the time clock mentioned herein furnish a very compact and useful form of pay roll ledger in which the names of employees need be written only once in three months, and may be used to considerable advantage and with a saving of time.

The "loose leaf" system will be found very convenient for the book-keepers, and may be used in several ways in the accounting. The principal advantages of its use are the ready manner in which the leaves may be removed and entries made on them by the typewriter, and the fact that all pages that are filled up and not needed from day to day may be removed and filed in transfer cases.

In the calculations of time and cost some mechanical aids will save much mental drudgery and give a feeling of security as to correct results. A number of good machines of this class are in the market, among them the Burroughs, Universal and Standard Adding Machines, the Locke Adder and the Comptometer. In even a small plant some one of these machines will be a welcome and useful addition to the office equipment.

CHAPTER XXVII

THE PROBLEM OF APPORTIONING THE FIXED CHARGES

Estimating. Cost keeping. Productive and non-productive costs. Diversity of opinion among accountants. Errors of the old systems. Popular idea that the expense of a proper cost system is greater than its benefits. Good judgment necessary. Lumping non-productive expenses. "All costs are productive costs." Ascertaining costs by a fixed machine and man rate. A percentage by averaging the total costs except those for labor and material. Dividing expenses into an unnecessarily large number of classes. The life of the machine taken into account. Accounting for the burden of fixed charges is the problem. Qualifications of a cost clerk. The "simple plan" is not a cost system. The two general plans. The time, or hourly plan. The labor cost plan. What are fixed charges. The expense burden. Supplemental expenses. The general burden. The proper system. Cost of land and buildings. Cost of light, heat, and power plants, and permanent fixtures. Insurance, taxes, water rates, maintenance, depreciation, etc. Area of floor surface. Non-productive expenses. Ascertaining the expense burden of a machine. Depreciation and interest. Classifying machines as to cost. The burden of idle machines. Importance of this factor. Faults of the old system of equipping the departments. A practical illustration. The proper method. The five factors of cost. Drawing room and pattern shop expenses. The floor space plan. Machine burden in the pattern shop. Charging the cost of regular patterns. Tool room costs. Work on regular orders. Work on tools, jigs, and fixtures. Burden of idle machines. Cost of consumable tools and supplies. Cost of transportation of material. Cost of machine repairs. Rebuilt machines. Calculating the cost of power, lighting, heating, etc. The value of this cost system. Important facts may be ascertained. Pointers for better management. Shows what departments are the more efficiently managed. Unnecessary machines. The fluctuations of business. Not a relatively expensive system. Showing where the troubles are.

The purpose of this chapter is to point out the methods for ascertaining and apportioning the fixed charges, office and salary, as well as the miscellaneous expenses, including those for interest and depreciation of machines and allowances for idle machines, all usually comprised under the general head of "burden." A prominent writer on the management of machine shop plants as commercial enterprises once wrote, "Upon the ability of the proper official to make correct estimates depends, to a very large extent, the commercial success of all manufacturing enterprises"; and in this aphorism he embodied much truth. Admitting the truth and importance of his statement, we are

nevertheless forced to the conclusion that were he to write of machine shop management in these times of sharp competition and close calculations he would also give a prominent place to the system of cost keeping and its numerous ramifications, pervading as they do every kind and class of material, from the time it enters the building up to its shipment.

The urgent desire for information is well illustrated by the editor of a mechanical journal, who says, "There is no inquiry which comes to this office more often than the request for sources of information on machine shop cost keeping." And he might have added that in this search for information there could hardly be a question upon which there would be a greater diversity of opinion. The reason for this is not far to seek since the science of correct cost keeping (if we may so dignify it) is as yet but imperfectly understood and the ever varying conditions where it must be attempted render the application of any large number of fixed rules impracticable.

It has often been said that there are many ways of accounting for the time spent on the different jobs in the shop, and for dividing the so-called productive from the non-productive expenses in this direction, but there is a still greater diversity of opinion and practice in accounting for the burden of fixed and miscellaneous expenses, as well as for properly ascertaining them.

When they are all considered and brought out in all their diversified aspects, and in proper relation to each other, the result may surprise many good accountants as well as business men and proprietors, who have used the old methods of assessing a certain percentage of the cost of material and labor as the proper burden which they should bear in calculating the actual cost of the product. This being a level percentage (though jobs may be in large variety and done at a bench, or on a power-driven thousand-dollar machine), is usually in error, sometimes too great, but often too small, and the result, even if the entire establishment pays a profit, still leaves uncertainty as to its source, since there are parts of the work done more economically than others, and some departments which should properly be credited with producing more profit owing to the better local management.

In the case above cited, the head of a department who manages his working force and his equipment with the greater skill and forethought has to assume a part of the burden that another foreman partly avoids. When the cost of individual parts, or separate operations upon them, is not known, we lose sight of opportunities for improving upon manufacturing methods.

Many realize the practical advantages that might accrue from a thorough knowledge of manufacturing costs, but have an idea that the expense would be greater than the benefit. It is, however, practicable to ascertain with considerable accuracy just what portion of the product has been manufactured at a loss and what portion was sold at a sufficient profit, as well as to ascertain

what departments of the shop are the more efficient, in order that the proper investigation and remedy may be applied to those which are not up to the proper standard.

To show the great diversity of opinions and practices in the matter of ascertaining and apportioning the burden of fixed and miscellaneous charges in different shops at the present time, the following instances are given as stated by the manufacturers or the accountants themselves. They show the views of the several gentlemen and the various methods used under the varying conditions of manufacturing, as well as the great variety of the product.

In one manufactory the man who has charge of the cost-keeping says that a great deal of good judgment is necessary in distributing the fixed charges and the cost of non-productive labor, but thinks that if all money paid out for these expenses is charged to *some* account all will be well. It is true that a good deal of good judgment is necessary; in fact in the best and most exact system for ascertaining and apportioning the multitude of expense items we may find problems solvable by no common rule. These must of necessity be decided by the highest rule of all, the rule of judgment, founded upon practice and experience. It is not enough to say that we may simply charge the large variety of expenses to *some* account and then expect any reasonable degree of accuracy in ascertaining detailed costs, for the reason, as before stated, that we shall overcharge some articles of the product while others do not bear fair share of the normal burden of expense.

Another manufacturer says that the expense of the entire superintendent's department, including foremen, plumbers, electricians, watchmen, the drawing room, general repair department, pattern shop, etc., should be considered as non-productive, while the next manufacturer says, "In our factory we do not recognize that there is any such thing as non-productive costs. *All* factory costs with us are productive costs, because they enter into the costs of goods produced." Here is a wide divergence of opinion and practice.

Again, a manufacturer has this method. He has a fixed price per hour for each machine and the man who runs it. This charge added to the cost of material is the "flat cost," to which is added a percentage of fixed and non-productive costs as ascertained month by month, or once in three months. This plan comes nearer being correct, provided the proper method is used to determine the amount charged on account of the machine.

At present it is sufficient to call attention to the fact that the correct valuation of the machines, the floor space occupied, the power required, and what we shall do with the cost of those that are occasionally or frequently idle, as they occupy the floor space, which must be kept clean with the machine, and this costs, excepting power and lubrication, as much as if the machine were performing profitable operations, is a matter of much importance.

Still another manufacturer gets at his non-productive costs by the percentage which this amount bears to the combined labor and material costs. The resulting percentage is used for the next six months and so on. The fixed percentage can be added to each class of goods manufactured, or to individual machines, or even to machine parts. It would not be accurate if any one important item had fluctuated considerably in price, as is frequently the case, for the reason that an extra high price paid for a leading material, as pig iron for instance, in cases where large quantities of castings are used, would burden the job with more of the non-productive costs than it ought to bear, and correspondingly reduce those burdens on other jobs which required proportionately small quantities of iron castings. It is therefore evident that this plan is open to very serious objections.

Another manufacturer divides what he calls "miscellaneous charges," not including interest, rent, insurance, etc., into no less than fifty-seven accounts, one of which contains seventy-five subheads or classes. This would seem like an unnecessary number of accounts and a plan by which the practical information to be gained would hardly be worth the care and cost. While these various items enter into the calculations of non-productive miscellaneous costs, and it may be useful to know the cost of the different classes of material and supplies purchased at different periods, or supplied to the various departments, for purposes of comparison, these considerations need not necessarily become a part of the cost system, by which we understand the actual expenses of *all kinds* properly chargeable to the production of the goods when ready for the market, under whatever particular heading they may be charged.

The next manufacturer, perceiving the point that the value and usefulness of the machines, and their cost as to floor space occupied, power required to drive them, and their maintenance, are proper factors in the problem of accounting for costs, proposes that in calculating a percentage of depreciation on the value of a machine, "the life of each machine should be learned as nearly as possible and the percentage of that life which would be used in making a given number of articles should be charged against such given number," etc., a sort of "life expectancy," as the life insurance man would say, but what cost clerk would want to serve as an "actuary" in an establishment where there are several hundred machines and as many different kinds of parts or articles to estimate upon. This plan would call for additional clerical assistance, which is one of the conditions we seek to avoid. We must not forget, however, that some such plan would be valuable in considering large and expensive machines which are not in continuous use, and are often idle for days and perhaps weeks. In such cases the interest charge is relatively high and the depreciation charge relatively low compared with less expensive machines in practically continuous use. These considerations add to this

many-sided problem and render it more perplexing as we endeavor to give the varied factors proper attention and weight.

In accounting for the actual costs of the product, and fixing upon an adequate plan, we are confronted principally with the problem of accounting for the burden of fixed charges, non-productive labor, and miscellaneous expenses, and it is just here that many otherwise good accountants fail to show the facts and conditions that it is important to know.

While the cost clerk must be a good bookkeeper, with a clear insight into all the clerical phases of the problems involved and an ability to prepare correct records of the business transacted, he must also often reason as a mechanic with a certain array of facts, in order to deduce from them conclusions of value to the degree of efficiency the shop has attained in the manufacture of a machine part and its efficient routine through the works. These conditions will be puzzling to a man who is simply a commercial accountant. We should hardly expect that a bank accountant would be much of a success in handling the cost system of a manufacturing establishment.

We may easily ascertain the sum total of all fixed charges and miscellaneous expenses, and so divide this sum as to have "all moneys paid out (except for material and labor) charged against something," but this method could hardly be dignified as a cost system. To properly divide and apportion these costs is the correct aim and sphere of a cost system if it is to be a valuable aid in understanding the details of manufacturing and increasing the efficiency of equipment and employees.

Two general plans are frequently used for this purpose and their variations adapted to suit individual conditions. In the first of these the method charges to each job a percentage of the total burden of fixed and of miscellaneous expenses in proportion to the number of hours of direct labor. This is found by dividing the total burden of expenses by the total number of hours worked for a given period, say three or six months, or a year, thus obtaining an hour rate which may be added to the cost of labor and material to make up the actual cost of the job. This plan is defective, as it places all classes of labor, skilled or unskilled, and whether working with a few hand tools or with an expensive machine, on a level. By this method a job done largely on machines would not bear its fair share, while the job done at a bench, by hand, will bear excessive burden. Such a plan could only be of any reasonable degree of accuracy where the employees were on a near equality as to wages and the work done on machines of nearly equal cost, floor space and power. These conditions will seldom be met, hardly ever over an entire factory and we might say never in a machine shop.

The second plan apportions the expense burden on a basis of the direct labor cost for each job. In this case the total burden is divided by the total

amount paid for direct labor for a given period (as before), and, using this quotient as a percentage of burden, it is to be added to the cost of direct labor and material on each job. The fallacy of this plan is that it takes no account of the very important factor of time. For instance, if a low priced man occupies twice the time in doing a job on a certain machine as a man getting twice the pay, it naturally follows that while the cost of labor has been the same, the cheap man has occupied the machine twice as long and yet the burden charged against the machine has been the same. This is manifestly wrong, and might easily make a great deal of difference in the correctness of the outcome, particularly in a shop where there is a great diversity in the cost of the machines, and in fact render the system useless so far as giving accurate results or even uniform results.

While the time or hourly plan corrects some of the defects of the plan of percentage of burden to the cost of labor plan, it brings in quite as erroneous ones of its own. It takes no cognizance of the value of the machines used, whether they cost a hundred dollars or a thousand, and a speed lathe might be assessed with just as much burden as a 72-inch planer. Again, a boy earning six dollars a week would count for as much by this plan as a machinist getting three dollars a day, so far as the expense burden is concerned. This plan would work many glaring errors, particularly in a manufactory with a large variety of machines and where the work ranges from comparatively small to quite large and heavy parts. In manufacturing establishments where the work is quite uniform and the machines upon which it is done are nearly of the same first cost, and where the wages of the operatives do not vary to any considerable extent, either of the above plans may answer all reasonable purposes.

But if we are to carefully examine the matter we shall see that where these conditions do not prevail we must look for some plan better suited to the prevailing conditions, and one that, while necessarily more intricate and expensive to administer, will tell with a reasonable degree of accuracy the costs of our products of whatever class, weight, or material, and enable us to know when and where losses and profits occur and what class of product, what department, or what individuals are responsible for the one or the other.

By "fixed charges" will be understood interest on the cost of land, buildings, and fixtures, insurance, taxes, water rates, etc. By "expense burden" will be meant the cost of so-called non-productive labor, the cost of power, lighting, heating, and ventilating, cleaning shop, interest on cost, and the depreciation of value of machines, etc. By "supplemental expenses" will be meant the burden charge on idle machines, etc. By "general burden" will be understood the sum of all three of the above charges.

Each machine forming a part of the equipment of the manufacturing

plant should bear a portion of the general burden according to its first cost and annual depreciation, and incidentally an additional portion due to the fact that some of the machines are sometimes idle, therefore earning nothing. Each employee not working at a machine should have a due portion of floor space burden charged in addition to his wages. Since the only source of revenue is that derived from the manufactured product sold, it follows that all expense of whatever kind must be borne as a burden upon the manufacture of these products for the market.

The entire volume of work in the shops is made up of a succession of jobs, each of which has a distinguishing number. They may, however, be classified as product, improvements, repairs, tool making, experimental, and so on.

We may properly commence with the first expenses incurred, the cost of the land upon which the buildings are erected. Then the cost of the buildings. Then the cost of the power, lighting, heating, and ventilating plants, and the plant for the transmission of power, including shafting, belting, electric wiring, dynamos, motors, lamps, and all fixed accessories. In this list of costs are all partitions, railings, shelvings, bins, racks, benches, fixed desks, shop railway tracks and cars, office fixtures and furniture, shop telephones, and all similar appliances not directly connected with the machines. We will add these costs together and ascertain the interest upon the amount per year.

To the amount thus ascertained we will add insurance on buildings, fixtures, etc., taxes, water rates, depreciation and maintenance of buildings, cost of furnishing power, light, heat, and ventilation, per year. To this add also the salary of superintendent, assistant, office force, foremen, watchmen, errand boys, etc., and office maintenance. This will cover our fixed charges plus the expense burden, which is to be divided by the area of floor surface in square feet, giving the burden which every square foot must bear whether occupied by a machine, a work bench, or as an erecting floor or other use. This expense must be gotten out of the sale of product in such a manner as to bear in equal proportion on all jobs in considering carefully the difference of the value of the use of the equipment involved in each of them individually.

Having ascertained the burden due to cost of buildings, power, lighting, heating, ventilating, and maintenance, together with the wages of so-called non-producers, so far as these will be constant, or very nearly so from year to year, we next consider the question of the burden due to the expense of the equipment of machines required for the work contemplated.

It has been pointed out that by one of the plans discussed the difference in time was disregarded, and in another the difference in wages, while in both the difference in the cost of the machines upon which the work was done was lost sight of entirely. In this present plan the method of properly accounting for this burden will be explained.

To ascertain the expense burden of a machine we first consider its first cost, then its annual depreciation, the insurance upon its value, and lastly the expense to house and drive it, in order to fully cover the conditions of the case.

It is customary to fix 10 per cent on the first cost of a new machine for annual interest and depreciation. For the next year we subtract 5 per cent from the original cost and use this result in fixing the next valuation. To this amount we add the expense burden of so much per square foot of floor space occupied by it and its operator, as found by the expense burden percentage previously explained.

While it will not usually be convenient to go over all the machines each year and assess them separately as to their cost, neither will it be necessary as they may be divided into groups or classes on the following plan: those costing $500 or less; those from $500 to $1,000; then by even thousands upwards. Every machine should be numbered in large, plain figures on a conspicuous part, and its special rate recorded in a book kept by the cost clerk, giving its changed rate each year. The employee using a machine will note on his job time card, in a space provided for that purpose, the number of the machine, for the information of the cost clerk, who may thus assess the proper expense burden on the job.

There is one more element or factor of burden. This is the hourly burden of idle machines, or the supplemental expense, and is disposed of in this manner. By having on the job time cards the numbers of all the machines in actual use, and having the numbers of *all* machines in the shop, the cost clerk readily knows what machines are not in use. An account of the machine rates thus incurred is kept during the month and distributed pro rata over the jobs during the succeeding month. While this is not strictly correct in theory it will be found equitable in practice and is much more easily accomplished than an attempt to follow up each job in the department containing the idle machines and distribute this burden among them before the account on each was closed.

There is an important point gained by this account of the machines idle, in the whole shop, and also in the different departments. It tells a very graphic story of the management of the department in keeping all the machines at work, and the opportunity for placing them in other departments where they will be more constantly employed, or disposing of them altogether. It should be very distinctly kept in mind that every idle machine means lost money.

One of the expensive drawbacks of the older practice of building an entire machine in one department, and another machine of different type or size in another department, rather than to so divide the work as to have the depart-

ment equipped with machines of one type (as planers) and the next with another type (as lathes) and so on, is that while one department will be crowded with one class of work, say planer work, the next one will have their planers idle and the lathes will be crowded. The author remembers one shop arranged after these ancient ideas in which, by actual count, nearly two thirds of all the machines of the plant were idle at a time, and largely owing to the above causes, thereby throwing on each machine in use the expense burden belonging to *three* machines. This meant that the shop in general was equipped with about three times the number of machines necessary to do the required work by a modern organization plan, and therefore lost that much money unnecessarily.

By our plan all the machines of a class or type are located in one department, and the departments so arranged that in the natural succession of operations the work passes from the first department to the adjoining one whenever possible, and so continues until completed. Thus we get the maximum of continuous service from the smallest number of machines and have very few idle ones, consequently the minimum burden of this character.

By our plan of accounting for the cost of a given job we find it made up of five separate factors or charges, brought together by the cost clerk. These are: first, the cost of direct labor; second, the cost of material; third, the fixed charges; fourth, the expense burden on the machines used; and fifth, a due proportion of extra burden on account of idle machines.

The drawing room and pattern shop expenses require special notice. In the usual discussion of shop costs perhaps they have not had a fair share of attention. It often happens that both drawings and patterns are directly chargeable to certain jobs as are of special nature. In calculating these charges we go about it in the same general manner as in ascertaining the cost of jobs in the machine shop proper. That is, charging for time occupied, material used, and to this is added a burden of fixed charges and an expense burden consisting of its proper proportion of the cost of non-productive labor, lighting, heating, ventilating, and cleaning, which, in the drawing room, will be assessed by the total area of floor surface occupied by this department divided by the number of men employed, to ascertain the burden rate per man, which is to be added to the time and material cost.

In the pattern shop the same method is used for men whose work does not require the use of a machine. For those who work continuously at a machine the same method as employed in the machine shop will be used, the machine having a regular rating. Frequently the machines are used only for a fraction of an hour at a time, and the cost is hardly worth the time it will take to ascertain it. This charge will naturally fall into the fifth factor of cost.

Under other circumstances both drawings and patterns are required for the regular output of machines or other articles manufactured. While these might in many instances relate only to a certain size or type of machine to be built, it would seem quite evident that the expense should be added to the fixed burden, for the same reason that we charge office furniture or shop fixtures, they becoming an asset of the establishment.

One of the machine shop departments about whose expense there seems to be much diversity of opinion is the tool room. It is liable to be employed on quite a variety of work, sometimes on orders for product to be sold, but more often for the making or repairing of tools, jigs, and fixtures for use on the machines in the manufacturing departments of the machine shop. When at work on regular orders, or any part of them, the charge will be the same as if the work were done in the machine shop proper, the machines in use here being rated in the same manner.

It is also clear that in making or grinding tools for lathe and planer work, cutters for milling and gear cutting, etc., and for making, altering, or repairing jigs and fixtures, we are adding so much to the equipment and its usefulness, and the expense should be borne by the machines in the machine shop on which they are used. Therefore it would seem proper that a percentage on first cost and for depreciation should be added in with the fourth charge in calculating the cost of a job. Of course this charge should only apply to the machine shop proper and the burden not carried to the accounts of other departments outside of it. It may be noted that the handling of the tool room accounts should be done cautiously, as a careless apportioning of the costs may lead to very serious errors.

The burden of idle machines in the tool room must be borne by the fifth factor in our cost account, for the reason that they are engaged either directly or indirectly in the production of the articles to be sold, the manufacture of which requires the use of the tools and appliances here made and maintained in useful condition.

Consumable tools and supplies such as files, waste, oil, etc., used on machines, drawn for use in the machine shop proper, will be classed as a part of the fourth factor of cost. This will not include waste and oil issued to the power plant, although the costs eventually find their way into the same group of charges.

The transportation of material or parts of machines being built, whether moved by shop railway, trucks, or cranes, becomes a charge on the job. In case of the use of trucks or the shop railway the machine rate, if we may so call it, has been considered already. In case of large traveling cranes, the crane is considered as a machine and rated accordingly. Where a man is required continually in attendance upon it his time may be charged to the

fourth factor of cost. The same may be said of sweepers and such helpers as are sometimes engaged on general work not properly chargeable to any particular job.

Cranes serving only one machine are considered as a part of that machine and so charged in fixing the machine rate. Electric motors by which machines are driven should properly be considered as a part of the power plant, whether they are operating individual machines or line shafts driving a number of machines.

The cost of all repairs on machines should be kept and once in six months 5 per cent of the amount accruing during that time added to the machine rates. If the cost of repairs is comparatively slight the account may run through the entire year. If a machine is practically rebuilt a portion of the amount charged off for annual depreciation must be restored to its value.

In calculating the cost of power, lighting, heating, and ventilating we must not forget that if there are some buildings somewhat isolated from the main buildings of the plant they should be assessed somewhat more per square foot of floor area on account of the added cost of conveying power, light, and heat to them. These conditions should be carefully investigated and the burden put where it belongs. Unless the distance is considerable these variations of cost will not be very important, yet our cost system should show their influence.

While our cost system is primarily intended to show the actual costs of all work done, it does, if wisely administered, show us other facts equally important in the successful management of a machine shop or manufacturing plant. For instance: if the cost of a certain job is noticeably higher or lower than usual we may easily ascertain why it is so, as we may consider the five factors going to make up the actual cost of the job and find at once in which of them has been the loss or gain. It will be readily understood that a high priced man may be the more economical, as the time occupied on the job will be less and consequently the machine burden less, while the reverse will be true with cheap help.

We may also see that with the work plentiful and the charge for idle machines running up, there is something wrong in the department where it occurs, and apply the needed remedy. It will show us which department is the more efficient and turns out its work the cheaper. It will show which department is the more economical in the use of consumable supplies. It will show the relative cost of machine repairs in the different departments. It will show in any of the departments where new machines are asked for, whether those already in use are profitably occupied, and if not, we may investigate the reasons for their not being used and the advisability of their removal to another department, and possibly the substitution of a machine better adapted to the special needs of the work.

These conclusions cannot be so ascertained by any of the prevailing methods of averaging all or even the principal part of the factors that go to make up the total cost of the work done. By the use of the fifth factor, that of a proportion of extra burden on account of idle machines, we may get a good idea of what portion of the costs may be due to the fluctuations of business prosperity or depression. It may be argued that this system is intricate and expensive to administer. In proportion to the importance of the facts brought out this is not relatively true. If we really want the information in detail and in as accurate a form as the conditions will permit, we must pay for it in some way.

Often in the expensive school of sad experience we may know that something is going wrong, but we cannot assure ourselves of why, when, or where the trouble is located. By this plan we know all the facts worth knowing as we go along, and they cannot but be valuable aids in machine shop management. It will be noted that in this chapter we have not covered the matter of marketing the product, therefore the expenses of advertising and selling, as well as a proper percentage of profit, must be added to the costs as ascertained by this cost system in order to arrive at what shall be the selling prices of the goods manufactured. But as compared with properly ascertaining the actual factory cost of the product, this is a comparatively easy problem to solve.

CHAPTER XXVIII

THE DRAFTING ROOM

The department of design. The real work of the draftsman. Routine of the room. General rules. Keeping the time. Drawing materials. Tracings. Poor materials is poor economy. Brown or black prints. Sizes of drawings. Too many sizes not desirable. Drawing cards. Desirable scales for drawings. Dates on drawings. Draftsmen's names on drawings. Shade lines. Dotted lines. Center lines. Dimension lines. Dimension figures. Conventional section lining. Titles. Plain lettering desirable. Mounting blueprints. System of machine symbols. Designation of machine parts. Marking patterns. Part numbers on drawings. Storing and filing drawings, tracings, and blueprints. Construction of drawers for holding drawings and tracings. Separating drawings and tracings into groups. Strawboard filing sheets. Indexing and filing drawings. Issuing and recovering drawings. Orders for blue or brown prints. Card system for filing, issuing, and recovering blueprints. Adhering to the regular system.

The drafting room is the department of design, where we expect ideas to originate for improving the product of the shop, as well as the methods of doing work. It should have the most accurate and efficient, and at the same time the simplest system and routine in its daily work. The draftsmen should be relieved as far as possible of clerical work. Their minds should not be burdened with a long list of symbols or complicated rules. They should be free to give their best attention to the real business for which they are employed, that of designing and drawing, and thus make the drafting room in fact, what it is often facetiously called by the machine shop men, "the brain room." Therefore the men at the drawing tables should not be concerned about the making of blueprints, their mounting, their issue to the shop, or their recovery and storage. This is properly the duty of apprentices under the direction of the chief.

The routine of the room should be carried on quietly. Orders should be given only by the chief. Employees from other departments should be excluded unless sent by their superiors upon inter-department business. Draftsmen should not work over eight hours a day and should not be expected to sit at the board more than two hours continuously. If designing, this period may be too long, without the relaxation of walking about for a quarter of an

hour. More and better work will thus be done and with considerably less fatigue to the men.

The time of the men on all work should be carefully kept on time cards in connection with a time recording clock, in order that the cost may be known with the same accuracy as in the machine shop. For this purpose each man registers both day time cards, showing the amount due him on the pay roll, and job time cards giving the time spent on each job and aggregating the same time as recorded on the day time cards.

One of the things which ought to receive careful attention is the selection of proper materials, particularly drawing paper and tracing materials. White drawing paper for the ordinary sizes of regular sheets should be purchased in rolls 36 or 48 inches wide and of such quality as to stand hard usage under the erasing rubber; to have a surface hard enough not to gather dust readily and yet with sufficient grain to take the pencil and ink easily; to lie perfectly flat on the drawing board and to be capable of damp-stretching if necessary. That of medium thickness will generally give the best satisfaction.

Tracings should be made on tracing cloth 36 inches wide and with a dull back. "Imperial" tracing cloth, while rather more expensive than some other kinds, is the more economical in the end. It is poor policy to pay a draftsman for the extra time wasted by poor tracing cloth. The dull back cloth is convenient for applying a pigment or soft lead pencil to the back in ordinary sectional views where a quick job is required.

Tracing paper should be used only for temporary jobs of a simple character. The same may be said of the use of bond paper, which has deceived so many draftsmen with the idea that the original drawings and tracing may just as well be made on one piece of material as a matter of economy. Such a tracing will become cracked and ruined in a short time, even with careful handling, while its tendency to wrinkle makes it a source of continual annoyance to the blue printer, who also finds that the pressure necessary for a good contact with the blueprint paper must be much more than with tracing cloth, or the prints will be blurred and indistinct.

The use of brown or black prints for such small diagrams, foundation plans, sketches, etc., as are sent to outside parties, is to be commended. These prints are very convenient and present a good appearance, particularly when the first print is used as a negative and preserved, while the prints from it, in brown lines on the white surface, are sent out. Where brown prints are used, any letters or figures to be filled in should be done in brown ink.

The most convenient size of drawings for use in the shop will depend to a considerable extent upon the product. While a large drawing may be very convenient, in that it displays the work on a large scale and is easily read by workmen, it is at the same time clumsy, often in the way, and more liable to

accident than a smaller one. But if the drawings are too small they must often represent the work on so small a scale that the lines and dimensions will be crowded, and necessitate small letters and figures, whereby the liability to errors by the workmen is much increased.

It is, of course, much more convenient to handle and to care for small drawings than large ones, both in the shop and in the drafting room, and the smaller sizes are not nearly so liable to injury. If we assume that the whole sheet or unit of our sizes is 24 x 36 inches, we may conveniently obtain the following sizes with no waste of drawing paper, tracing cloth, or blueprint paper, namely: double sheet, 36 x 48 inches; whole sheet, 24 x 36 inches; half sheet, 18 x 24 inches; quarter sheet, 12 x 18 inches; and sketching sheet, 9 x 12 inches. Ordinarily, construction drawings can be confined to the first two sizes, while for very large sheets a quadruple size of 48 x 72 inches may be used. These large sizes will readily fold to fit in a drawer suitable for 24 x 36 inch sheets, which will be preferable to rolling them. In folding such drawings care should be taken not to press the folds so firmly as to cause deep creasings, with the danger of the paper giving way by repeated folding. The best sizes for use in the shop as well as for handling in the drafting room will be found to be 18 x 24 inches and 24 x 36 inches, the former having the preference. It is advisable to confine the drawings for the shop to one size if it can be done without sacrificing convenience and efficiency to the demands of uniformity.

In the manufacture of small parts in large numbers it is often a matter of great convenience to use thick cards, 9 x 12 inches, with round corners, upon which a drawing of a single piece is made. The drawing is varnished on both sides with at least two coats of bleached shellac, that on the back preventing the warping of the cards due to the varnish on the face. These cards are convenient to handle and store and are economical, as no mounting is required, and they are much more durable than might be supposed.

When drawings are not made full size, the question of the most desirable scale should be carefully considered, with a view to selecting one not so large as to fill the sheet too much, or so small as to crowd the various parts shown. That scale is best with which the draftsmen may work with least liability to error. Many find that the scale of half size, or 6 in. = 1 ft., is very unfortunate in this respect, and most of them will no doubt prefer the quarter scale, 3 in. = 1 ft., whenever it can be used. The eighth scale, $1\frac{1}{2}$ in. = 1 ft., is properly a favorite where a smaller scale is desired, while the general drawing of a large machine completely assembled may require a scale of $\frac{3}{4}$ in. = 1 ft. or 1 in. = 1 ft.; but this will seldom occur in the usual course of machine drawing.

The scale should always be clearly marked on every sheet. If it is drawn

full size, that should be stated. The fear that machinists will measure a drawing rather than depend on the figures and thereby make errors in the work is a needless one under nearly all circumstances, and is largely overbalanced by the convenience of having the scales plainly indicated in all instances. It is equally important that the dates be given. On a construction drawing the date when it is commenced and when it is completed should both appear. On all other drawings the date should be that of completion. This should be supplemented by the dates of alterations made on the drawing and the dates of the original tracing, and any subsequent ones made necessary by such changes.

All drawings should show when and by whom the dimensions are checked. The name of the draftsman should appear in full on all construction drawings and his initials on all other drawings or tracings. These precautions will often greatly facilitate following up a design and the subsequent changes in connection with it.

Considerable controversy has been had on the point whether shade lines are appropriate on mechanical drawings. When the arguments are all in it would seem but fair to say that there is no good reason why they should not be used and several very good reasons why they should. One reason only appears necessary for using them — they make the drawing much easier to read by the machinist, hence there is less liability to error, and less time is spent by him in deciphering complicated drawings.

Dotted lines should have the dots and spaces of equal length and ordinarily not less than ten dots to the inch. Center lines should consist of a succession of dashes separated by two dots, the groups of two dots and one dash occupying about $\frac{5}{8}$ inch. Spaces as above. Dimension lines should be a series of dashes separated by one dot, and of lengths and spaces as above. All dimensions up to 3 feet should be given in inches and common fractions of an inch; dimensions greater than 3 feet, in feet, inches, and common fractions of an inch.

When work requiring fine measurements is to be drawn it will be found necessary to use decimal dimension figures rather than to use the smaller common fractions of an inch — therefore the use of decimal fractions should be encouraged. For fine work they are practically indispensable. The numerator and denominator of a common fraction should never be separated by a diagonal line, but always with one parallel to the dimension line. Gothic figures should always be used, the lines of which should be of equal width throughout. Figures should read properly when the sheet is so held that the title reads properly. When this cannot be done they should read properly when the sheet is turned with its right-hand edge next to the reader.

Sections may be distinguished on tracings by going over the back of the

tracing with a soft lead pencil, depositing enough of the lead to show well in the blueprint. If it is desired to distinguish the material of which the part is made we must resort to section lining conventionally adapted to this purpose. The most useful of these forms are shown in Fig. 179. It will be noticed that the method is to represent similar materials by similar forms of lining, which assists in memorizing the forms; also, that the more common materials are

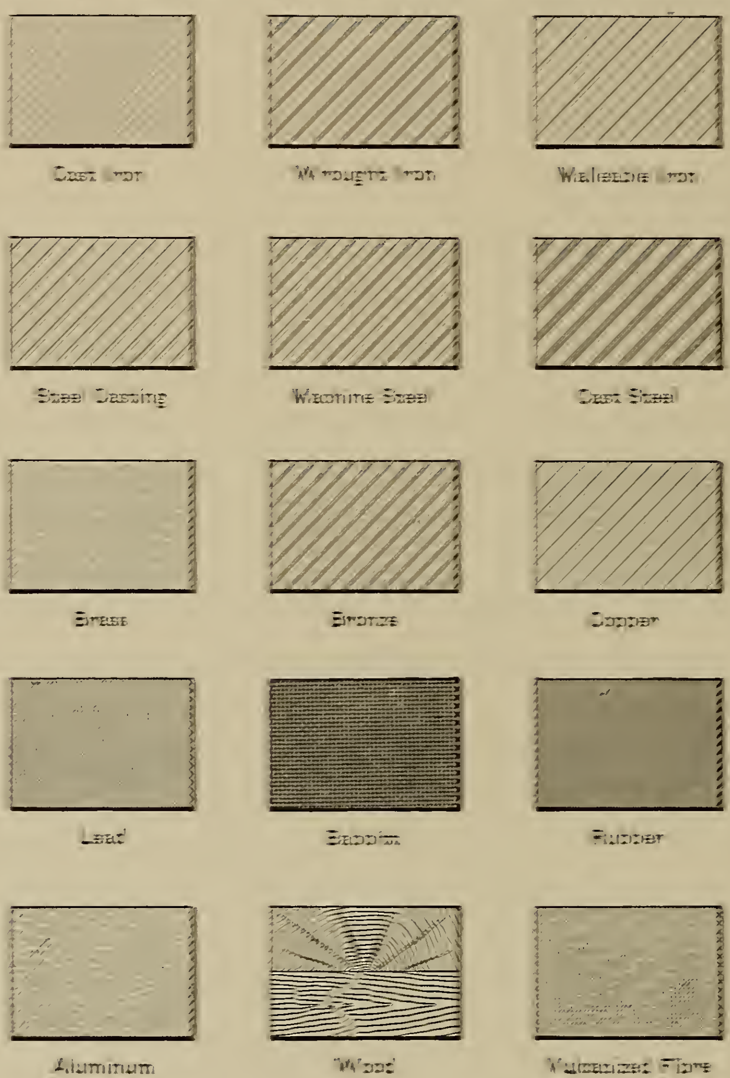


FIG. 179.—The Conventional Indication of Materials on Drawings.

the more simple and easy to represent. Some draftsmen prefer this plan and in addition using the soft pencil on the back for increasing the effect. It adds but little to the time of making the tracing.

Another much discussed question of drafting room practice is that of titles on drawings, and what may or may not be considered proper as to the matter to be included. On this subject opinions vary all the way from the use of a simple serial number to matter enough to constitute a veritable history in brief. There are several points to be considered in the matter. The title should contain enough information to be of practical use and at the same

time to tell its story briefly. It should tell us what set of drawings it belongs to, naming the machine; what part of the machine it represents; the scale to which it is drawn, and the date when it was completed.

On construction drawings the date when it was commenced should also be given. It should show what draftsman drew it; when and by whom it was traced, checked, and altered. It should give the name of the establishment. Then we shall not have to refer to an index book, or to a card index whenever we wish to ascertain any of these facts; and as the foremen or workmen are not provided with these useful accessories they will not have to annoy others, or to go to the drafting room to ask questions about it, as would frequently be the case if blueprints contained, as titles, only such marks as "24-A-5," meaning that it belonged to machine No. 24, could be found in drawer A, and that it was sheet No. 5, all of which is of very little use to the man in the shop who uses it, however sufficient it may be in the drafting room.

Yet it is of use to have each machine distinguished by a symbol, or letter, and the particular tracing and blueprint by a number. These numbers begin with 1 for each machine, hence they do not usually run into more than two figures. They are a convenience to the draftsmen in finding them in the drawers, as well as of designating them briefly. This form of title is shown in Fig. 180. The plainest lettering should always be used, hence the gothic form for important letters and figures, and the draftsman's italic for the smaller ones, will be the most economical to make, the easiest to read, and consequently the best adapted to practical use both in the shop and in the drafting room.

12" ENGINE LATHE.
GENERAL DRAWING OF
HEADSTOCK.

Scale, 3"=1 ft. Name of Company.

Drawn by L.T.F. 6-12-'04	Traced by G.T. 6-14-'04	Checked by J.K.M. 6-15-'04	A	2

FIG. 180.—Title on Drawings. Usual size, $2\frac{1}{8}$ x 3 in.

Many methods have been advocated and experimented upon to determine the best way to mount blueprints for use in the shop. One method is to have boards half an inch thick with cleats nailed to the ends, and not increasing the thickness of the boards. These boards are painted on both sides and have the blueprints laid upon them and held down by pine strips $\frac{3}{16}$ x $\frac{3}{4}$ inch, fastened with 8-ounce carpet tacks, for easy removal. This method renders the blueprints very convenient for the shop and preserves them well, as the strips prevent their defacement by other boards coming in contact with them. However, blueprints mounted in this manner occupy considerable space.

Another method is to mount the blueprint on heavy strawboard or binders' board. In this form an extra sheet of equally strong paper should be pasted on the back of the strawboard to prevent warping. Blueprints mounted in this manner are quite convenient to handle in issuing, returning, and storing,

and with even heavy strawboard they are light and convenient for the shop. The corners should be clipped off or rounded.

Still another method is to mount the blueprint on sheet iron. This has been tried with blueprints of moderate size, but it would seem that these can not be very convenient to handle on account of their weight, and would be liable to injure each other if piled up, by defacing the lines and figures. The edges of the sheet iron will be rather harsh to the hands. If properly performed the method of mounting blueprints upon heavy strawboard will be found as good as any for sizes of 18 x 24 inches and 24 x 36 inches, while for small work the 9 x 12 inch cards as described above will be found very useful.

Several systems are in vogue for indicating the different machines built, and these symbols are carried into the system of the drafting room for the purpose of identifying drawings. One of these methods is by distinguishing figures, another by letters, and more frequently by letters and figures combined, the one representing a class and the other indicating its place in that particular class. It will need no argument to prove that the more simple this symbol can be the easier it will be remembered, the less time it will take to represent it on drawings, and the less space and expense will be required to attach it to patterns.

When the number of different machines to be built does not exceed thirty or forty the letters of the alphabet may be very conveniently used; in the more frequent cases a single letter only being required. This will be readily seen from the scheme which follows, and is adaptable to a shop building machine tools in a moderate variety.

A, 12-in. Engine Lathe
B, 16-in. Engine Lathe
C, 20-in. Engine Lathe
D, 24-in. Engine Lathe
E, 30-in. Engine Lathe
F, 36-in. Engine Lathe
G, 45-in. Engine Lathe
H, 60-in. Engine Lathe
J, 24-in. Planer
K, 30-in. Planer
L, 36-in. Planer
M, 48-in. Planer
N, 60-in. Planer
P, 16-in. Upright Drill
Q, 24-in. Upright Drill
R, 30-in. Upright Drill
S, 40-in. Upright Drill
T, 10-in. Shaper
U, 16-in. Shaper
V, 24-in. Shaper
W, 10-in. Slotter
Y, 15-in. Slotter
Z, 20-in. Slotter

The letters I, O, and X are omitted for the reason that the letter I is so near in appearance to the figure 1, and the letter O to the cipher, that they are likely to cause confusion. The letter X is omitted as it is used to indicate changes in a pattern, as will be presently described. Other machines may

be indicated by two letters instead of one, thus: AA, 9-inch bench lathe; BB, 12-inch hand lathe; CC, 20-inch special lathe; DD, 24-inch forming lathe. Or a 36-inch planer widened to 48-inch, instead of having its patterns and parts marked L, will have those made necessary by the change of width marked L-M, the last letter indicating 48 inches wide. In the same way a 36-inch lathe raised up to 45-inch swing may have the extra parts needed marked F-G. The hyphen is introduced to indicate that two machines are being considered in the designation. The letters of the alphabet having been exhausted in this manner, other combinatious may be resorted to, as AB, BC, etc., omitting the hyphen, as only one machine is meant to be referred to. This system will be found to have many advantages, not the least of which will be the ease with which these symbols are committed to memory.

In designing the parts of a machine the list is divided into sub-heads or groups of related parts. An engine lathe list will be divided into the bed, headstock, tailstock, carriage, rests, countershaft, etc., each of these headings including the principal piece mentioned, and all its related parts or appendages. In fixing the designation numbers to the various parts the bed would be 1, and the other parts following in regular order. When all the parts of this group are numbered a sufficient number of blank spaces are left for additions in this group. Then the next group is proceeded with in the same manner. The similar parts in several machines of the same class will receive like numbers, the distinctive letter symbol of the machine designating the individual part, pattern, or drawing thereof. For instance, the headstock of a 20-inch lathe may be designated C40, while that of a 36-inch lathe would be F40, and so on.

When a pattern or a part is altered the fact is indicated in red ink on the original drawing, and on the pattern a letter X is added to its former designation. Thus, the headstock of a 20-inch lathe when altered becomes C40X, each successive alteration adding another letter X to its designating mark, or in case of several alterations, one X, followed by a figure indicating the alteration, may be used. Thus, for the fourth alteration the mark would be C40X4. The red ink on the drawing gives the date when the change was made. Parts may be numbered in groups with reference to the materials of which they are composed. For instance, numbers 1 to 499 may be assigned to cast iron parts; 500 to 599 to malleable iron parts; 600 to 699 to steel casting parts; 700 to 799 to brass parts, and so on for forgings of wrought iron and steel and for the parts machined directly from the bar stock, etc., since every part made or purchased should have its distinctive number in order to carry out not only the drafting room system but that of the other departments of the works. In all drawings the part number should appear in a small circle to attract attention and to distinguish it from the dimension figures. It

should be placed directly on the part where possible; otherwise at one side with an arrow.

Various schemes have been advocated for storing and filing drawings, tracings, and blueprints. It will be conceded, no doubt, that unmounted blueprints, drawings, and tracings should lie flat in drawers, and be so placed that the title at the lower right-hand corner may be readily accessible. The drawers should be constructed as shown in Fig. 181, with a strip A at the back, $\frac{1}{4}$ inch thick and 3 inches wide, to keep the back edges of the sheets in place and to prevent injury. There should be a separate drawer for the drawings of each machine, whose name and distinctive letter should be plainly marked on its front. A similar drawer for each machine holds the tracings, the two being kept in separate cases of drawers. For conveniently finding and replacing sheets the best method yet suggested seems to be that of separating them into groups of ten by interposing strawboard, properly indexed, as shown in Fig. 182. These sheets perform the double office of ready reference to the sheet wanted, and in the case of tracings they serve to keep them flat. The top sheet of strawboard bears the machine name and letter. This sheet should be an inch larger all around than the drawing or tracing, while the indexed sheets should be still an inch wider on the right-hand side so as to admit of ready indexing with plain figures.

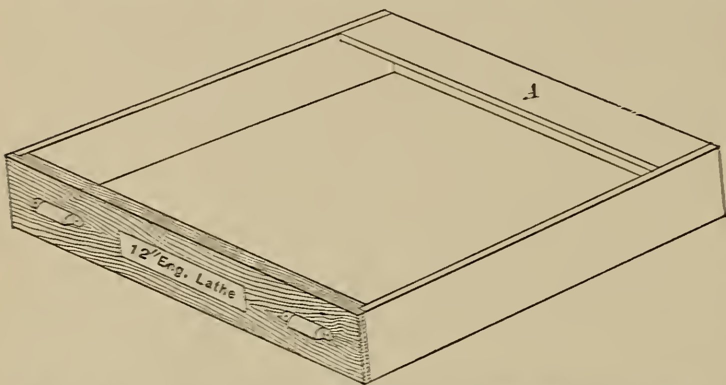


Fig. 181. — Drawer for Drawings, Tracings or Blue Prints.

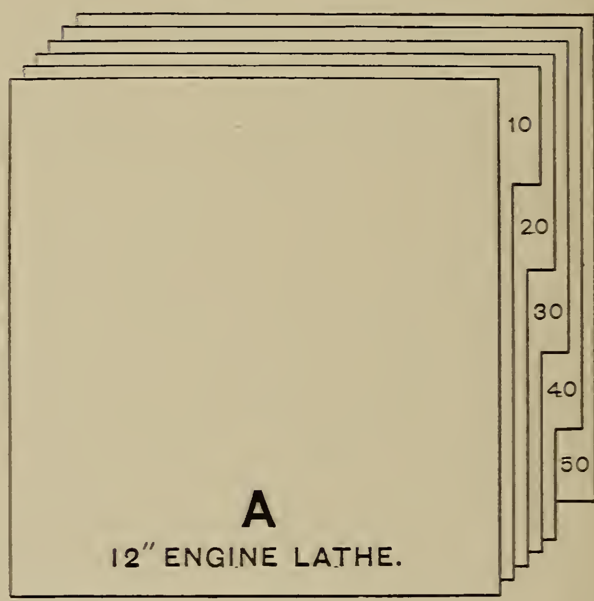


Fig. 182. — Index Cards for Drawer. Strawboard.

Blueprints mounted on strawboard may be laid flat in drawers, or be stored on edge, in a case, as shown in Fig. 183. On the shelf beneath each compartment is marked the letter and name of the machine.

Indexing, filing, issuing, and recovering drawings, tracings, and blueprints is undoubtedly best handled by the card system. As each machine is designated by a letter, the first card, pink in color, will bear on its tab the letter of the machine. As the parts of the machine are divided into groups

of related parts, the first card of the group will bear on its tab the name of the group, usually taken from its most important part. For instance, in an engine lathe the groups will be the bed, headstock, tailstock, etc. One of the

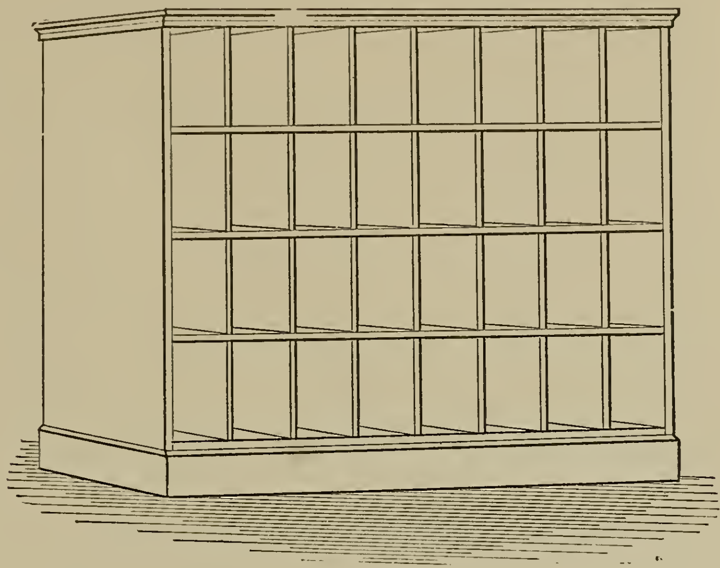


FIG. 183.—Case for Storing Mounted Blue Prints.

group index cards is shown in Fig. 184, and a machine index card in Fig. 185. The arrangement of these cards and of the others in the different groups is shown in Fig. 186. The group index cards are white. By this arrangement it is very easy to find any particular card wanted. The cards relating to one machine may be divided from those of another by a loose wooden partition a quarter of an inch thick if desired. It is considered by some draftsmen as a convenience rather than a necessity.

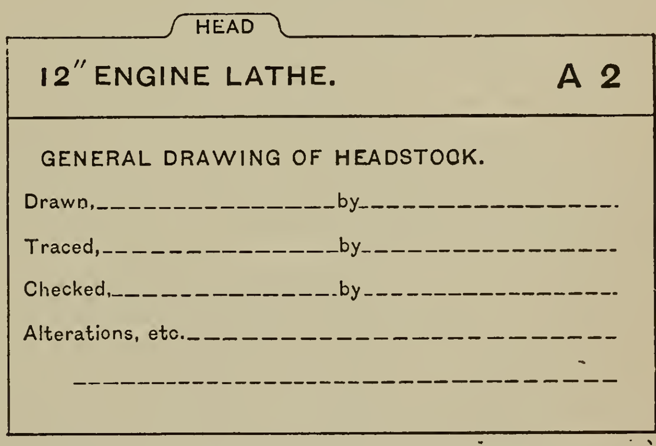


FIG. 184.—Group Index Card, size, 3 x 5 in. Color, White.

When blue or brown prints are wanted the chief will give the blue printer an order card of the form shown in Fig. 187. If for blueprints he will use a blue card, and for brown prints a brown card. If for brown print negatives he will add the word "negatives" to the title line on the card. This card, properly dated, will be turned in to the chief with the prints when they are completed.

When blueprints are to be mounted they are issued by the chief, and when completed a card will be made for each of them, whether duplicates or not, like that shown in Fig. 188, which is light blue. These cards will be arranged the same as those for drawings and tracings, with tabs for the groups

of parts. The cards separating those of different machines will be red, and of the form shown in Fig. 189.

When blueprints are issued the entry will be made on the cards showing

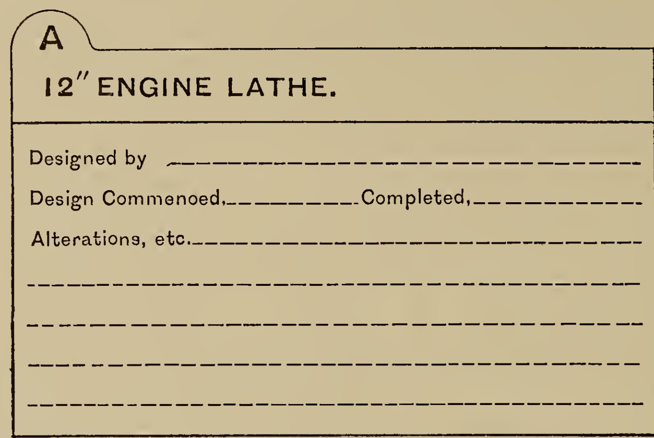


FIG. 185.—Machine Index Card, size, 3 x 5 in.
Color, Pink.

the date of issue and to what department they went. When they are returned the date will be stamped in the proper space. When the card is filled up a

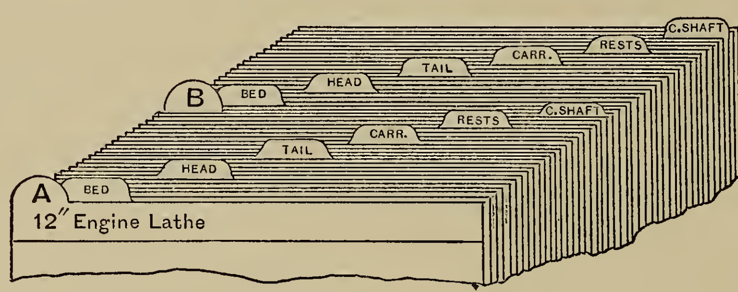


FIG. 186.—Locating Index Cards in the Drawer.

new one takes its place. The chief draftsman, receiving a copy of all orders for work sent into the shops, will make his arrangements for blueprints in ample

ORDER FOR PRINTS.

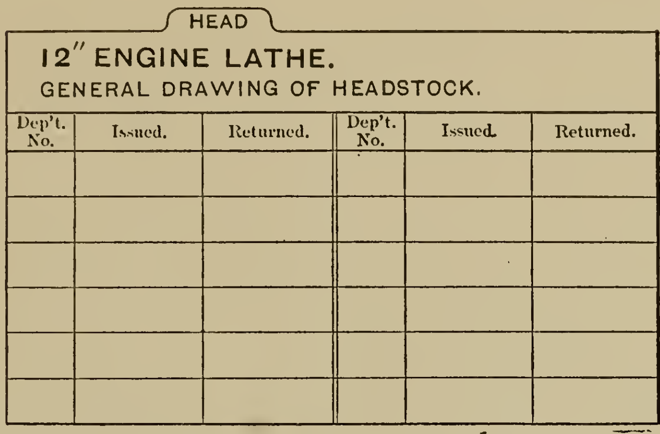
Date Ordered.	No. Wanted.	Letter and No.	Date Made.

________________________Chief Draftsman.

FIG. 187.—Order for Prints. Cards, 3 x 5 in. Color,
Light Blue for Blue Prints; Brown for Brown Prints.

time to meet requirements. Drawings and tracings are not supposed to be sent into the shops, and the making of temporary sketches of any part in the

effort to hurry the work along should be discouraged, as mistakes and misunderstandings are liable to occur, while by always adhering to the regular system we shall insure the prompt fixing of responsibility for errors, and the smooth running of the routine affairs of the department.

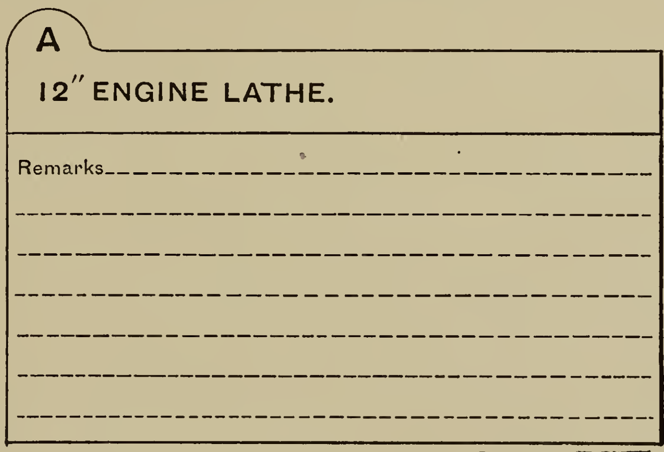

HEAD

12″ ENGINE LATHE.
GENERAL DRAWING OF HEADSTOCK.

Dep't. No.	Issued.	Returned.	Dep't. No.	Issued.	Returned.

FIG. 188. — Blue Print Record Card, sizes, 3 x 5 in.
Color, Light Blue.

In fact the effort to find "short cuts" in transacting the business of the establishment, while in a certain sense commendable, should only be taken up when it is amply demonstrated that such a course can be safely followed. It is too often the case that a slight saving in one direction may result in a waste of time in another. It will be well to consider the work of the Drafting


A

12″ ENGINE LATHE.

Remarks

FIG. 189. — Blue Print Index Card, size, 3 x 5 in.
Color, Red.

Room from rather a conservative standpoint in these respects, as a slight error here is liable to lead to much trouble all the way through the shops. Hence the work here should be done with deliberate care and thoroughness to insure the success, not only of this department, but of those which follow it in the regular routine of manufacturing.

CHAPTER XXIX

THE TOOL AND STOCK ROOM

The lack of information in reference to it. Only special portions of the subject heretofore taken up. Disconnected parts of systems. The need of a complete system. The tool room. Here it should be treated in reference to other departments. Its two sections, the tool-*making* and the tool-*keeping* rooms. Equipment of the first section. General plans of the room. Auxiliary tool-distributing rooms. The tool room foreman. Question of ordering tools. Relation of the tool room to the general shop routine. Time keeping. The time card. Foreman's orders. Stock and material accounts. Material and cost card. Work on the regular product. Cost keeping of this work. The tool room design. Building partitions. Tool-keeping room. General arrangement. Shelving. The double check system of issuing and recovering tools. The check board. Storing and issuing files. Tracing the tools. General rules. Operation of the check board. Errand boys. Permanent issue of tools. Standard sets of tools. System of caring for jigs and fixtures. Card system for locating, issuing, and recovering them. Stock room arrangement. Shelves, drawers, boxes, etc. Location of different articles. Special equipment for tool and stock rooms. Stock room supplies. Accounting system. Card system. Stock ledger cards. Consumable supplies. Finished parts. Storeroom.

THE studious mechanic, ever on the alert for new and up-to-date information relating to the equipment, arrangement, organization, and management of the modern machine shop or manufacturing plant, must have noticed, and with some surprise, the lack of discussion in the technical publications on the subject of the tool room, as well as the stock and storerooms, that in so many shops are intimately connected with all shop routine. Such discussions as we have had heretofore have usually been on particular features, such as tool racks, tool trays, tool checks, steel racks, drawer racks, tool check systems, and so on, but in none of them have we been favored with a complete system for the management of the tool room and the stock room.

Again, we find many descriptions and illustrations of tools, jigs, and fixtures, always interesting and valuable, often indispensable for their particular sphere of usefulness in the shop, but seldom do we see plans or descriptions of how or where to keep them in the best condition and ready for use. It is no doubt true that in many shops these expensive accessories are often left on benches or under them, or on wall shelves in the rooms where they are used, subject to dirt, dust, rust, and the possibility of accidental injury.

We find many disconnected parts of systems for use in the stock or store-room; how stock shall be ordered; how it shall be accounted for when it is received; how it shall be issued; how it shall be followed up to know what is on hand, what needed, etc., but never a complete system of management giving the details from the time stock is wanted until it is finally expended and accounted for.

It is proposed, in this article, to take up these matters in regular order, and to describe and illustrate, as fully as is here possible, the regular routine from the inception of a requirement until its final realization.

First to be considered is the tool room. This should be located apart from the general machine shop, as a too intimate connection does not seem desirable in practice, while it is self-evident that it should be convenient to the superintendent's office, drafting room, and pattern shop, and that it should be well lighted, comfortably warmed and ventilated. This room is properly divided into two sections, the first being the room where tools are made and kept in proper repair, and the second, the room where they are stored, repaired, issued to the machine shop as required, and received from the shop when no longer needed there.

The second section may consist of two parts, in one of which lathe and planer tools, milling cutters, drills, taps, reamers, files, jigs, fixtures, gages, and similar articles are kept, while the other part may contain the articles of stock and consumable supplies usually found in the ordinary stock room, such as machine, cap, and set screws, oil cups, metals, the smaller bar and sheet stock, bolts, rivets, nut blanks, oil, waste, emery, emery cloth, etc. It will be much more convenient in many ways to keep these two classes separate for storage purposes as well as for accounting and issuing.

It is assumed that the machinist portion of the tool department, or the tool-*making* room is equipped with modern machine tools sufficient in number, variety, and efficiency to turn out all the tools, jigs, fixtures, gages, etc., that may be needed. This equipment may consist of a 24 in. x 5 ft. planer, a universal milling machine, an index milling machine, a 10-in. shaper, a sensitive drill, a 25-in. upright drill, two 18 in. x 8 ft. tool room lathes, one each 24 in. x 10 ft., 20 in. x 10 ft., 16 in. x 6 ft., engine lathes, a 12 in. x 6 ft. speed lathe, a 6 in. x 18 in. surface grinder, a 4 in. x 30 in. grinder for cylindrical work, a disc grinder, three tool grinders, and two twist drill grinders. Also, the necessary large and small surface plates, straight edges, and similar tools and accessories that may be necessary for the production of good tool work.

It is also assumed that adjoining this room is the room wherein tools, jigs, gages, fixtures, files, etc., used in the shop are kept, and in connection with these, in the same room, or one opening from it, is kept such stock as

machine, cap, and set screws, round, square, and hexagon tool and machine steel, brass, copper, and steel wire, sheet brass, copper, steel, and fiber, rough bolts, nut blanks, washers, and all similar articles of stock usually found in the machine shop storeroom, as well as belting, oil, waste, and similar consumable supplies.

For convenience of administration all these may be under the charge of the tool room foreman, while the special work of caring for, issuing, and receiving tools and the issuing of stock may be taken care of by a tool and stockkeeper and a young man, and perhaps a boy. There should always be two persons conversant with the location of every item of tools and stock in these rooms, so that the regular work may not be impeded in case of the illness or unavoidable absence of the man in charge.

The engraving, Fig. 190, presents a plan of these rooms, laid out in the

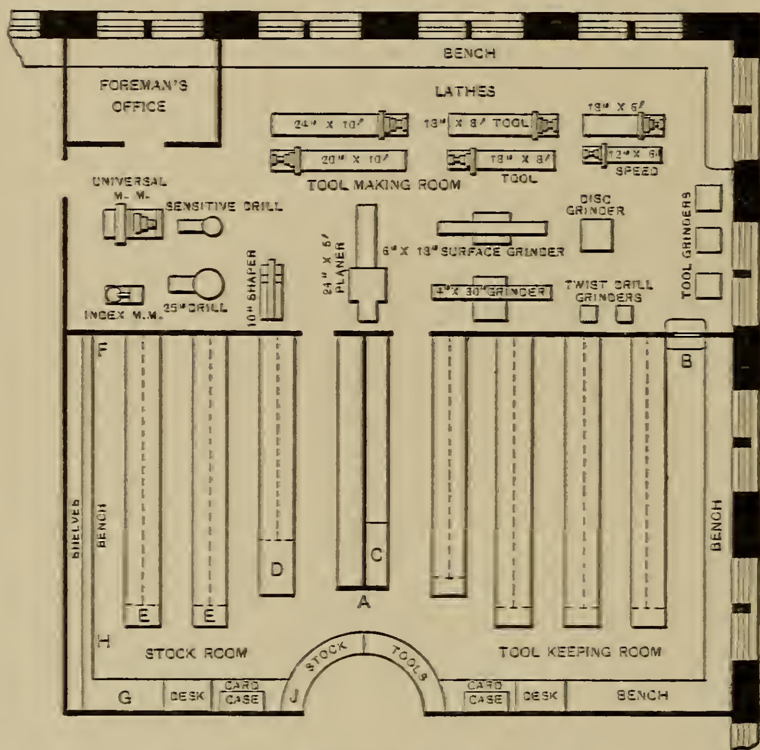


FIG. 190.—Plan of a Tool Department.

most convenient manner, showing the location of the machine tools in the tool-making room and the various sections of shelving, racks, bins, counters, benches, etc., in the tool storeroom and the stock room, all designed and arranged with a view to efficiency and economy of operation, as well as the economical use of the floor space. This design is a variation of the one shown in Chapter XVIII and is designed as a secondary or alternate study to that one. It will be found useful to those about to organize the tool and stock rooms of a machine shop or factory in a practical and economical manner, and at the same time not sacrifice the important factor of efficiency.

In addition to this general tool room there may be other distributing

points, as the offices of the several foremen, or auxiliary tool rooms at remote points on the ground floor, or on other floors in case the shop is constructed with several floors. At these points, lathe and planer tools, twist drills, and similar tools may be had by the workmen without sending to the general tool room for them. If this is the case the regular routine of issue by the general tool room will be preserved as though the issues were made directly from it. To carry tools to these auxiliary tool rooms a device similar to the cash or bundle carriers in department stores should be used, while for carrying tools to and from other floors a conveyor consisting of two chains running over pulleys at the upper and lower floors, and provided with pivoted boxes, located between them, is very economical and efficient, and in successful use in some of the largest shops and factories.

The foreman of the tool room is supposed to have a small office, that he may have a proper place for keeping the records of the work of the department, as well as a private room for convenience in making such sketches, plain drawings, or details as he may find necessary in carrying out the plans for tool making, these not being always worked out in sufficient detail by the drafting room force, or such as he may wish to devise himself for special work, and to develop as the necessities for them may arise.

On general principles all drawings are supposed to be made in the drafting room, and by the regular draftsmen, yet there are times when the initiative in these matters may, with proper authority, be taken by the foremen of the tool room and the experimental room. In such cases the regular finished drawings of record should be made in the drafting room according to the regular rules of that department. In fact, it should be a rule habitually enforced in the whole establishment, that except for urgent reasons, or special orders from competent authority, the regular routine for transacting business should be insisted upon, and that "short cuts to avoid red tape" should be frowned upon and discountenanced.

When in the regular course of shop work, tools, jigs, fixtures, gages, etc., are required, the superintendent will issue a written order, of which he retains in his order book a carbon copy. These orders will be serially numbered, in duplicate (for general work in the shop in triplicate), and this individual order number will designate this particular work all the way through such departments as do any work upon it.

As the plan of organization I have advocated provides for two assistant superintendents, the first having under his jurisdiction the drafting room, pattern shop, tool room, experimental room, stock room, power house, iron foundry, forge shop, carpenter shop, paint shop, shipping room, and yard gang, while the second assistant superintendent has charge of the strictly manufacturing departments, an order for tools will go to the first assistant,

who in turn will write in a carbon copy book a similar order for the foremen concerned in the work, furnishing a copy to the chief draftsman and to the foremen of the tool room, pattern shop, foundry, and forge shop, for the necessary drawings, patterns, castings, and forgings, respectively, and see that they are gotten out and furnished to the tool room foreman.

When the drawings are complete the chief draftsman will notify the first assistant, who, if he desires the job to go on at once, will direct him to send the proper drawings to the pattern shop and forge shop. In making these drawings, and in all subsequent work, the value of time and material will be charged on a material and a cost card of the form shown in Figs. 191 and 192.

NAME OF COMPANY.

MATERIAL AND COST CARD.

ORDER NO. ______________ DATE, __________________

STOCK	WEIGHT	COST	STOCK	PIECES	WEIGHT	COST
C.I. CASTINGS						
MAL. "						
STEEL "						
BRASS "						
BRONZE "						
BABBITT						
MCH. STEEL						
CAST "						
TOOL "						
WT. IRON						
PATTERN LUMBER						
BOX "						

FIG. 191.—Size, 5 x 7 in. Six Ply Cardboard. Color, Light Red.

NAME OF COMPANY.

TIME ACCOUNT.

ORDER NO. ____________ COMPLETED ____________

DEPARTMENT	AMT.	DEPARTMENT	AMT.

FIG. 192.—The Time Account (on the back of the Material and Cost Card).

The time account kept by the workmen is on a job time card which, in addition to the regular day time card, is registered in a recording time clock, a separate card being used for each job, and the aggregate amount of time so registered equaling the amount shown by the day time card. One of these cards is shown in Fig. 193, which is adaptable to the International card recorder time clock. At the end of the week these cards go to the office, the time clerk receiving the day time cards, and the cost clerk the job time cards.

The foreman of the tool room will make written orders in a carbon copying book to the different men doing the machine work in substantially

the form shown in Fig. 194, adding a sketch whenever the drawings do not fully show what is required, or that some special method is necessary, or when the sketch will render his meaning more certain than written words. A fairly good sketch with the necessary dimensions can scarcely ever be made to mean what was not intended. Sometimes writing is rather weak in this respect, particularly if it has been carelessly done. This order is retained by the workman as his authority for doing the work, and will often be found useful in settling disputed questions arising where verbal orders were depended upon.

WEEK ENDING ______________________

NO. ______________________

NAME

____

DAY	FORENOON		AFTERNOON		OVERTIME		LOST TIME
	IN	OUT	IN	OUT	IN	OUT	
MON.							
TUE.							
WED.							
THU.							
FRI.							
SAT.							
SUN.							

TOTAL TIME ____________ HOURS ________

RATE ______________________

TOTAL WAGES FOR WEEK ______________________

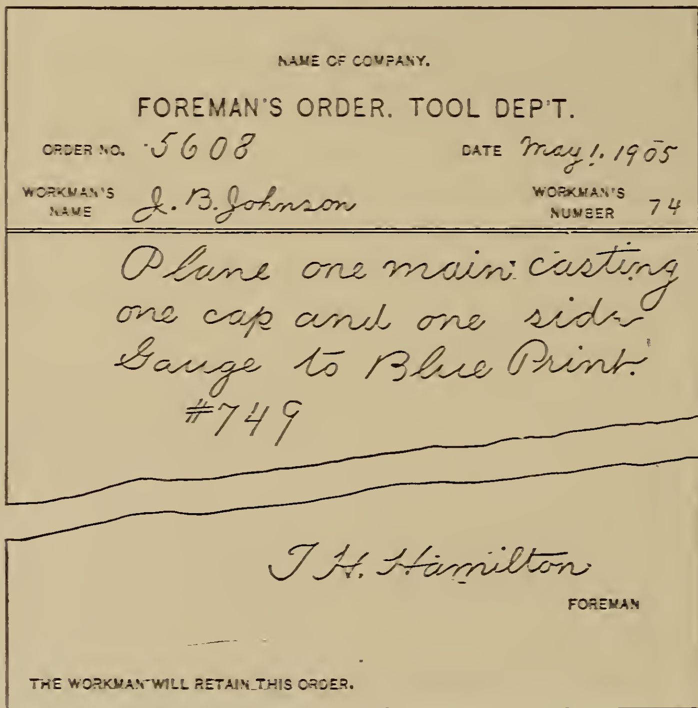
Fig. 193.—The Time Card, size, $3\frac{3}{8}$ x $5\frac{1}{2}$ in. Straw Colored Cardboard.

Whenever stock or material is required from the stock room, or from any other department, it will be drawn on a "Material" requisition of the form shown in Fig. 195. This requisition is written in duplicate, one part being retained by the foreman of the department furnishing the material, and the other part returned, with the material, with the costs entered upon it. Purchased parts require a similar requisition, of yellow paper, with the printed matter changed to suit its use. All stock and material drawn or received from whatever source will be entered on the material and cost card, so as to furnish an accurate account of all shop expenditures on the job as it passes through its various stages.

Any department other than the tool room doing any work on tools will send with the work their own material and cost card when the job is turned in to the tool room. These cards will be sent, together with the tool room card, to the cost clerk when the job is completed. The time of the foreman of the tool room will be charged against any order on which he may be nearly exclusively engaged, but this will seldom occur, and it will be safer as to general results to make his salary one of the so-called non-productive charges, the same as that of the other foremen, or the assistant superintendents. The same may be said of the errand boy who will be found necessary in this department. By the use of these blanks and the time card system there will by a minimum of clerical work to be done, and this may be easily handled be

the foreman who will thus keep in closer touch with the routine work, distribution of time, and the cost of the work turned out.

Occasionally the tool room does work upon the regular product of the establishment. There may be some machines in the tool room equipment which are better adapted for certain work than those in use in the manufacturing departments, or it may be that there is less tool making than usual, and some work is put into this department for the purpose of keeping the force engaged rather than to temporarily transfer some of the men elsewhere. When such work is done in the tool room it will be handled exactly as it would be in one of the manufacturing departments, and be subject to the same rules and routine, as well as under the supervision of the second assistant superintendent, who is in charge of the manufacturing operations in general.



NAME OF COMPANY.

FOREMAN'S ORDER. TOOL DEP'T.

ORDER NO. 5608 DATE May 1. 1905

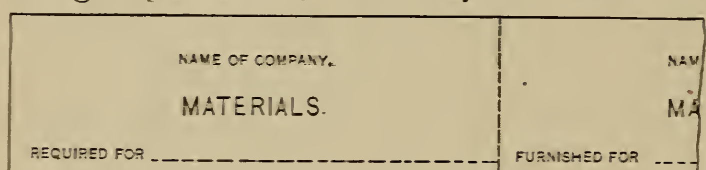
WORKMAN'S NAME J. B. Johnson WORKMAN'S NUMBER 74

Plane one main casting
one cap and one side
Gauge to Blue Print
#749

J. H. Hamilton
FOREMAN

THE WORKMAN WILL RETAIN THIS ORDER.

FIG. 194. — Foreman's Order, size, 4 x 6 in. Color, Light Blue.



NAME OF COMPANY.

MATERIALS.

REQUIRED FOR

ORDER NO. DATE

AMOUNT	MATERIAL	COST

NAM…

MA…

FURNISHED FOR

ORDER NO.

AMOUNT	

FIG. 195. — Requisition for Stock and Materials, size, $8\frac{1}{2}$ x 11 in. Color, Light Green.

The enclosing partition of the tool department should not be wholly of boards, as this will very much impede the light. Neither is it necessary that

it should be entirely of wire netting. A much better plan will be to build it of $\frac{7}{8}$-inch matched sheathing, set vertically, and to a height of 42 inches, being finished with a strip covering the top ends of the boards and another at the bottom to cover the floor joint. Above this woodwork should be four feet of wire screen, which may be tacked to 2 x 3 inch uprights, and finished at the top with a cap and molding. If something more expensive is desired, gas pipe uprights may support an ornamented iron rail at the top, and a wire screen of lozenge-shaped mesh may be used instead of that of square or hexagonal mesh. This screen need not be finer than 1-inch mesh, and the larger the mesh the less it will impede the passage of light.

The tool storeroom, or tool keeping room, shown in the plan, Fig. 190, is fitted up with a bench on two sides and a semicircular counter which, in conjunction with the stock room, furnishes a very convenient arrangement for receiving and issuing tools and stock. This counter may be closed with a wire screen in front, having in it an opening for each room through which articles may be passed. The counter should be 42 inches high and the benches 30 inches. A door may open beneath the counter and a portion of the counter top be hinged to turn out of the way to admit large packages of stock, as a bale of waste, a barrel of oil, etc. This opening need not be over 30 inches wide. The remaining space beneath the counter may be fitted with shelves for holding articles frequently called for, and so placed as to be in convenient reach.

The sections of shelving are made 30 inches wide at the bottom and 20 inches wide at the top. They are shown as divided in the center, providing two series of shelves from 10 to 15 inches wide. Should wider shelves be desired for some special articles this central division may be omitted. At the partition between this room and the stock room proper is a series of shelves 20 inches wide. The sections of shelves may be 8 to 10 feet high according to the quantity of tools to be stored. If much above ordinary reach there should be sliding step ladders at each passage. A portion of the front end of each section is arranged with cross shelves, of a width to suit the tools more frequently used, so as to bring them in convenient reach of the tool keeper. Upon the bench at the right of the room and upon one or two strong shelves beneath it may be stored large fixtures too heavy to be conveniently kept on the section shelves.

The tool check board shown in Fig. 196 may be located at A. At B is an opening above a broad shelf, where dulled tools, drills, etc., may be passed through to the tool grinders in the tool making room, and returned by the same way when ground, more conveniently than to carry them around by the door. Long arbors may be placed on end at the back ends of the passages, proper racks being provided for them.

Files should be kept in a case of pigeon holes of suitable dimensions, the smaller ones at the top, the coarser cuts at the left, and similar shapes of the different sizes under each other. A good arrangement is this; (reading from left to right): First shelf, flat bastard, flat second cut, flat smooth, fine mill, hand smooth, square bastard, square second cut, square smooth; for the next shelf, half round bastard, half round second cut, half round smooth, coarse mill, taper (triangular), round bastard, round second cut, round smooth. Thus two horizontal rows of eight pigeon holes each are required for each size from six-inch up. With the exception of special shapes, one row of eight pigeon holes will be sufficient for each of the three, four, and five inch sizes.

By the above arrangement the tool keeper will soon memorize the positions of each size and shape so as to handle them rapidly. There should be large spaces at the bottom for surplus stock, this space being more difficult to reach

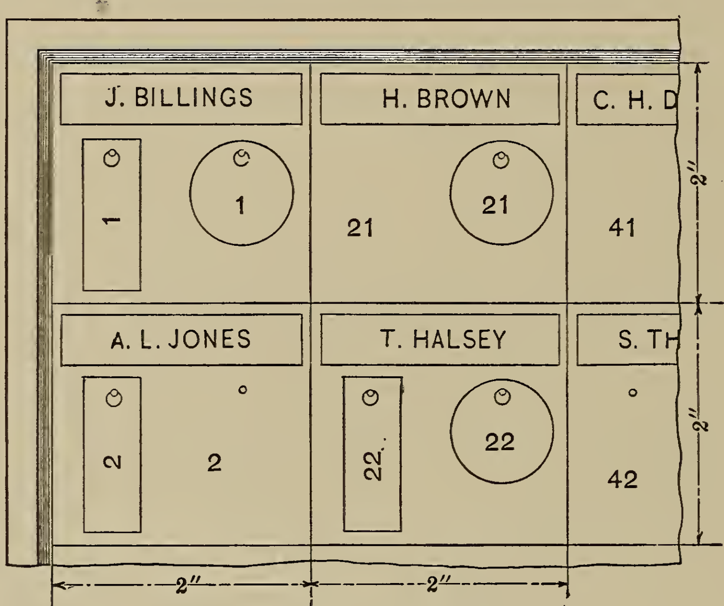


Fig. 196.—The Tool Check Board.

in the ordinary issue of files and quite as good for keeping surplus stock. The location of this case is at C, so as to be in convenient reach of the tool keeper.

There seems to be a great diversity of opinion as to the best system for issuing and receiving the ordinary tools kept in the tool storeroom, such as drills, taps, tap wrenches, reamers, etc. If we study the conditions of the case a little we will, no doubt, arrive at several conclusions that will help to solve the problem.

Some of these conclusions may be briefly stated as follows: The tools wanted should be delivered with the least possible delay. Therefore they should be so arranged that no time is lost in looking for them. Their location in the shop should be known whenever they are not in the tool room. Every man having tools from the tool room should be held responsible, not only for

the safe return, but for the condition of the tools while in his hands. Therefore the tools, as they are brought in, or as soon thereafter as possible, should be examined as to their condition, before the transaction is completed by the replacing of the tool check on the board. The time of the workman is too valuable to be spent in going after tools and returning them, or in grinding them. Therefore they should be delivered and returned by errand boys. These conclusions having been arrived at we may arrange a system in accordance with them.

The plan of using brass checks in issuing tools for indicating their location is most simple, and by the use of duplicate checks it can be made most efficient, giving at any time the location of any particular tool and also the number of tools in the possession of each and every man. For this purpose a board containing a list of names of all the men to whom tools are to be issued is provided, a small section of which is shown in Fig. 196. Beneath each name, which is printed or written on slips of cardboard, and tacked to the board with small brass pins, are two pins or hooks capable of holding a dozen brass checks. Two forms of checks are used. Circular ones about $\frac{7}{8}$-inch diameter with the individual number of the man stamped with $\frac{1}{4}$-inch figures. Another set of checks are $\frac{1}{2}$ x $1\frac{1}{4}$ inch, also with the man's number stamped upon them. The same numbers will also be stamped under the check pins on the board.

Twelve of these circular checks are given to each man and twelve of the rectangular checks are hung on the left-hand check pin beneath his name. When he sends for a tool he sends one of his circular checks. This is hung on the right-hand pin under his name and one of the rectangular checks is put in place of the tool in the tool rack or on the shelf. If he sends for another tool the circular check which he sends is added to the first one. Therefore the location of the tool is shown by the presence of the rectangular check in the tool rack, while the number of circular checks under his name shows how many tools he has out.

At the end of the week all tools are called in and the workmen's checks returned for the next week's routine. This is done so that if any mistakes have been made during the week they may be rectified. By this method we have only to glance at the board to see how many tools each and every man has in his possession, and if any particular tool is absent, the check in its place shows at once who has it.

By this system there are no cards to change, no books to keep, or written entries of any kind to make in the process of issuing and receiving tools, and as the work forms a considerable majority of the tool keeper's work, the saving of time over any system requiring written entries is about one half. Besides this, the soiled fingers of the tool keeper soon deface cards and books and should be avoided when possible.

There should be a sufficient number of errand boys at different points in the shop to quickly answer all calls for tools and to return them to the tool room promptly. Their wages will be small in comparison with the time that would be lost by the men in doing similar duty. With lathe and planer tools, etc., each operator should always have a spare tool at his machine in good condition for use. He may then take out a dull tool and send it to the tool room where it will be exchanged for a sharp one, and have no delay but in changing tools in his machine.

The original sharp tools only are charged to him at the tool room. These charges, as well as similar ones for tools used continually, are made upon cards containing the man's name and number at the top, following which is a list of tools in his possession for his regular work, and which he may retain for months, the dulled, worn, defective, or broken ones being replaced from day to day. The form of this card is shown in Fig. 197.

PERMANENT ISSUE OF TOOLS.

NAME ______________________ NO ________

TOOLS.	ISSUED.	RETURNED.

Fig. 197. — Permanent Issue Tool Card, size, 3 x 5 in. Color, White.

In the regular course of manufacturing work there are certain sets of tools, jigs, gages, fixtures, etc., required at one time. For instance, where a lot of holes are to be drilled and tapped there will be required a tap drill, a set of three taps, and a tap wrench. Or, where a certain machine part is to be milled there will be needed one or more milling fixtures with the necessary milling cutters. Or, a part to be drilled will require a drill jig and drills of the various sizes to go with it. These sets of tools and fixtures should be kept in separate boxes provided with a hinged cover, lock, and key. The contents of the boxes are plainly marked on the outside, as, for instance, "Milling, Part D-135," "Drilling, Part P-24," "Drill and Tap, $\frac{5}{8}$," etc.

In arranging these boxes on the shelves they should be grouped according to their purposes, or the machines to which they pertain. For instance, those for drilling and tapping, and the shelf so marked on its edge. Sets of jigs, gages, and fixtures should be grouped in a section of shelving according to the machines to which they belong, then grouped according to the particular

part to which they pertain. These sets of tools are issued only on a written order from the foreman of the department where they are to be used. They are accounted for by the card system in the following manner: There is a separate card for each set of tools. These are arranged in one or more drawers marked "Tools in," the guide cards showing the machines to which they refer, or, if general in character, the kind of tools, as drilling and tapping, drilling and reaming, etc.

When a set of tools is issued the card representing them is removed from its accustomed place and filed in another drawer marked "Tools out," the guide cards in which will indicate the department to which the set of tools were sent. When the set of tools is returned the card is restored to its accustomed place. Thus there is no writing necessary, the simple changing of a card answering all purposes of a book and being much more convenient for reference. Each card contains a list of all tools or pieces that are contained in the set.

At the left in Fig. 190 is shown the plan of the stock room, access to which for the purpose of drawing stock and supplies is by way of the area at the left, in front of the semicircular counter. This room is arranged in a similar manner to the tool keeping room, with sections of shelving between which are passages, or alcoves, for conveniently reaching any part of them. These shelves are arranged for the reception of boxes, drawers, sheet iron trays, or whatever form of receptacle may be needed for the particular form of small or large stock to be kept.

Up to a height of 42 inches these shelves may be formed as bins for holding the larger sizes of round and hexagonal head cap screws, set screws, washers, rivets, nut blanks, and similar stock. The smaller screws, as round and flat head machine screws, cap screws, set screws, etc., may be kept in trays or boxes, or left in the original packages on the shelves. Small stock, such as oil cups, brass cocks, gas fittings, etc., should be kept in trays or boxes, on the shelves. Bar stock, such as drill rods, square tool steel, round and square cold drawn machine steel, and similar stock, should be kept in deep pigeon holes, which take in nearly the whole length, and is provided for at D.

Sheet steel, brass, copper, and fiber should stand on edge, in a case provided with vertical partitions two inches apart, and may commence near the floor and consist of three or more sections, one above the other. These are located at E, E. Lubricating oils are kept in vertical cans holding a barrel each, and set in drip pans on the bench at F. Belting should be kept in the rolls, set on edge between upright partitions arranged under the bench at G, this location being selected for convenience in stretching out a piece of belting down the passage to the rear, in measuring it to the required length by brass-headed nails driven into the floor at proper intervals.

Waste, or whatever substitute is used in lieu of it, is kept under the bench at H. Stock issued by weight will be weighed on a proper scale located on the counter at J. Brass, steel, and copper wire in coils may be hung on brackets or pins over the shelves at the left side of the room. Small coils of wire, as of music wire for springs, should be kept in drawers or boxes on the shelves. In all cases the stock keeper will so locate his stock that the kinds most frequently called for will be the most convenient to reach, so far as it is possible to do so.

The construction herein described is of wood, for reasons of economy, as it can be built by the carpenters employed about the plant. It is not by any means the best construction, however, and several new and improved forms are in use that offer important advantages in several ways. One of these is a skeleton rack formed of uprights composed of thin iron castings set at any desired distance apart to accommodate sheet metal drawers which rest on horizontal ribs cast on the uprights, which are held together by rods and sections of pipe to act as distance pieces.

By this system the sections may be made of any length, and to suit drawers of any width. These sections are double and accommodate two series of drawers, their backs coming together. Only one pattern is necessary for these supports, the projecting ribs forming the drawer supports being stopped off in the outsides of the uprights at each end of the sections. If drawers of twice the depth of those usually used are desired, each alternate rib may be stopped off for that purpose.

Another method is to build up the sections of angle iron or steel instead of cast iron uprights, riveting on angle strips to act as drawer supports. In this case, too, the drawers are made of sheet steel. The sections are made as in the former case for two series of drawers, their backs coming together. Double depth drawers may be arranged for when the supporting strips are riveted on.

Both of these methods afford a considerable protection to their contents against fire, while their construction is such as to render them very serviceable and lasting.

Still another plan is to have the sections built of wood with the shelves inclined to the front about twenty degrees and their front edges provided with a strip one inch high. Upon these shelves is a series of sheet iron pans from 2 to 4 inches deep and of suitable length and width. Ordinary baking pans may be used for this purpose. There may be upright dividing partitions between the pans, or not, as may be desired. They are not really necessary and to use them adds 50 per cent at least to the cost of the sections over what it would be if they were omitted. The shelves are inclined for convenience in seeing the articles contained in them.

The method of keeping the stock room supplied with the articles necessary to issue, and the manner of issuing and accounting for them will next be considered. It is the duty of the stock keeper to see that he always has a sufficient quantity of all kinds and sizes of stock to meet the probable demands that will be made upon him. When more of certain kinds is wanted he will make a requisition on the purchasing clerk upon a duplicate form shown in Fig. 198,

NAME OF COMPANY. STOCK AND SUPPLY REQUISITION. NO. ______ DATE ______				NAME STOCK NO. ______	
AMOUNT	ARTICLES	COST		AMOUNT	

FIG. 198.—Stock and Supply Requisition, size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, Pink.

sending him the first half and retaining the other part as evidence of what he has called for. When the stock is received he will check off the articles on this blank, and wait for the invoice, which the purchasing clerk will send him. This he will check from his portion of his requisition, upon which he will enter the costs.

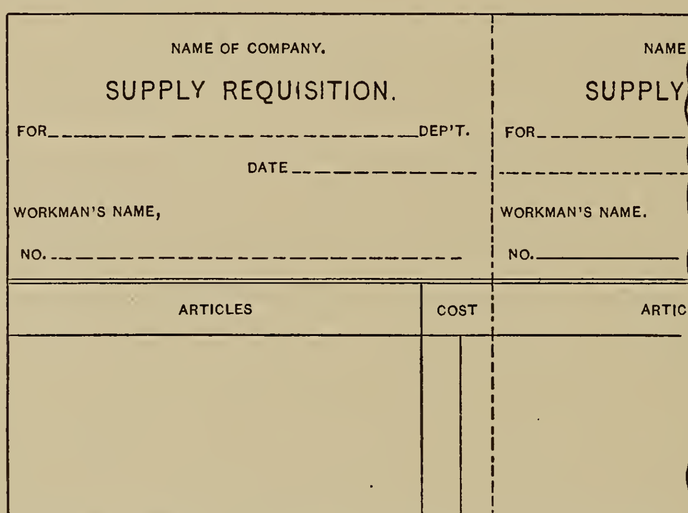
STOCK LEDGER CARD ARTICLE ______								MAX. ______ MIN. ______
RECEIVED		ISSUED						
DATE	AMOUNT	DATE	AMOUNT	DATE	AMOUNT	DATE	AMOUNT	TOTAL
FORWARD								
TOTAL ______		FORWARDED ______				TOTAL ______		

FIG. 199.—Stock Ledger Card, size, 4 x 6 in. Color, White.

In order to keep a correct account of all stocks received and issued; to know when a sufficient quantity of each article is on hand for issue; when to make requisition for more; and to be able to ascertain quickly at any time the amount of any one article on hand, the stock ledger card shown in Fig. 199

is used. There will be a separate card for each kind and size of stock. All stock will be classified and proper guide cards will readily show the location of each class of stock cards. These classes will be sub-divided when necessary, the class guide cards and the sub-class guide cards being of different colors. These sub-classes may be advantageously again divided in some instances. For instance: Class, cap screws; sub-classes, round and hexagonal heads; in each of these sub-classes, soft and case-hardened. Nut blanks, square and hexagonal. Sheet steel, machine steel, spring steel, and tool steel. Sheet brass, hard and soft, etc.

When stock is received it will be entered on the proper card, giving the date of its receipt. As quantities are issued the date and amount is entered at each issue, the total carried out on the horizontal line, and at any time added vertically and subtracted from the total amount received will show the balance on hand. When this card is filled up the amount on hand is ascertained and carried on to another card against the word "forward," and future operations entered as before.



NAME OF COMPANY.

SUPPLY REQUISITION.

FOR ________________ DEP'T.

DATE ________

WORKMAN'S NAME,

NO. ________________

ARTICLES	COST

NAME

SUPPLY

FOR ________

WORKMAN'S NAME.

NO. ________

ARTIC

FIG. 200.— Requisition for Consumable Supplies, size, $5\frac{1}{2}$ x $8\frac{1}{2}$ in. Color, Manila.

In order to prevent an unnecessary amount of any one stock, or of allowing the amount to get below a safe minimum, the stock keeper will watch the condition of his stock, note the amount issued within a certain time, and soon be able to fix maximum and minimum limits, within which the stock of each particular article is to be kept. These amounts he will enter on the upper right-hand corner of the proper card. Should his first estimate in this respect not prove correct he may change it on subsequent cards.

By careful attention to this point he may save much unnecessary outlay for stock kept on the shelves, and should any changes occur he will have less old stock to work off. Once every three months the stock on hand may be inventoried as a check on the card account. If found substantially correct these periods may be lengthened to six months.

All consumable supplies issued will be upon requisitions of the form shown in Fig. 200. These will always be signed by a foreman, or other authority. One part of this blank will be retained by the stock keeper, and the other part, with the costs entered upon it, returned with the supplies.

Still another division of the store or stock room may be a storeroom for small finished parts purchased from outside manufacturers. The general system of receiving them and accounting to the purchasing clerk, caring for them and issuing them upon proper requisitions, is the same as in accounting for stock and supplies.

CHAPTER XXX

PATTERN SHOP SYSTEM

A field for a good system of management. The poorly created shop. Its proper location and importance. Organizing the working force. Various kinds of labor necessary. Classifying the work. Qualifications of a skilled pattern maker. Selection of pattern lumber. A lumber drying room. Storing pattern lumber. The kind of lumber for patterns. How the lumber should be cut from the log. Economical use of pattern lumber. Caring for short lengths of pattern lumber. Working up scraps. Discrimination in the use of lumber. Fillets and dowels. System of marking and testing patterns. Making pattern letters and figures. The proper style of letter. Applying them to the pattern. Case for storing pattern letters. Care of wood fillets. The pattern maker's cabinet. Keeping wire nails, screws, etc. A color system for varnishing patterns. The pattern loft. Handling patterns. Overhead trolley tracks and trolley hoists. System of storing patterns. Pattern records. Card system for recording, issuing, and recovering patterns. Handling the card system. Time and cost keeping. Material and cost card. A complete system. Methodical and orderly management. Individual duties and responsibilities. The ideal pattern shop.

There is no department connected with the modern machine shop in which a good system of management, administered by a careful, methodical man, in a quiet and orderly manner, will be of more benefit to the establishment in general than the pattern shop. It is too often the case that this department is looked upon as being non-productive; a source of continual expense; not producing anything which may be sold at a profit; and consequently should be managed as cheaply as possible.

Therefore we see the pattern work done in a part of the shop not at all fitted for such work, possibly in one end of a machine room and subject to the iron dust and dirt which is not shut out by even a board partition, and sometimes by one only half the height of the room. We find it poorly equipped with inadequate and often obsolete machinery, supplied with poor lumber, and lacking many of the essentials for producing good work. Often men are employed because of the low wages they are willing to work for, rather than those of the requisite ability in their chosen trade.

There is always a vast difference between cheapness and economy, as the terms are generally understood, and these false ideas of economy generally result in the expenditure of more money finally than if such short-sighted

ideas gave way to the policy of seeking for the best, being willing to pay for it, and then expecting high efficiency of employees and the production of good work that would stand the test of hard usage, rather than that which must be frequently repaired and strengthened in order to keep it in use.

While these facts should be strenuously adhered to as to the regular work of the pattern shop intended for permanent use, we should not lose sight of the occasional jobs of pattern work intended for only a few castings, and therefore should be made with this end in view, and often at one half the expense of a thoroughly made, permanent pattern.

That there has been a good deal of improvement along these lines within the last few years is undoubtedly true, yet the fact remains that there is still in many shops room for more changes for the better, both in matters of economy of expense and a higher standard of workmanship.

The following plans and systems of handling the work are the result of practical experience as well as years of observation of this and kindred work, and it is hoped that they may offer practical suggestions to men having the responsibilities of administering the affairs of such a department.

In arranging the working force of the pattern shop a definite plan should be followed. This plan will depend to a great extent upon the kind of work that is to be done. That is, whether it is to be for large, medium, or small pattern, or perhaps a portion of each. Also, whether it is to be a good deal of new work, or a large proportion of the work is in altering patterns, or changing standard parts of them. In any event the one essential point to be considered is, to employ skilled or high priced pattern makers only on such work as need such ability, while all work that can be done by apprentices, or less skilled men, shall be done by them. For this as well as other evident reasons, getting out dimension lumber, making core prints, bosses, varnishing and marking patterns, and similar work, may be done by men at from half to two thirds of the pay that the skilled pattern maker receives. Therefore such machines as the planer, jointer, circular saws, etc., may be handled by the men who may be classed as "mill men," who, while they are not conversant with pattern making as a trade, can get out such dimension lumber as the pattern makers require in less time and at much less cost.

The same will be the case with the man running the band saw in getting out segment work and then laying it up. Being employed on this class of work continually, he can not only do just as good work, but sometimes better, than a man who only does it occasionally, and of course do more of it and do it more economically. Putting in fillets, puttying, plugging screw-head holes, varnishing and rubbing down patterns, etc., is the work of an apprentice and not that of a skilled workman.

To obtain the most efficient and economical results from this department,

assuming that the work will be in the usual proportion of new work, alterations, repairs, etc., its force and the duties of the men should be classified somewhat as follows: A force of fourteen employees would consist of say one foreman, six skilled pattern makers, one lathe man, one planer man, one circular saw man, one band saw and segment man, one finisher and varnisher, one man for keeping pattern records, lettering patterns, etc., and one laborer.

For a force of ten employees there should be one foreman, four skilled pattern makers, one lathe man, one band saw and segment man, one man for keeping pattern records, finishing, varnishing, and lettering patterns, etc., and one laborer.

For a force of seven men there would be one foreman, three skilled pattern makers, one lathe, band saw, and segment man, one planer, jointer, and circular saw man, and one man for keeping pattern records, finishing, varnishing, and lettering patterns, etc. A laborer must be called from the yard or some part of the shop when wanted.

By finishing a pattern is meant putting in fillets, plugging screw-head holes, puttying, etc. In a force of ten men the lathe man will do whatever other work the foreman desires when he is not engaged on his special work. The man who keeps the pattern records looks after the issuing of patterns to the foundry and the storing of them when they are returned. An apprentice should be able to put in fillets, putty, varnish, rub down, etc., and where there are only a few men the foreman will keep the pattern records.

It should be understood that when we speak of a skilled pattern maker we mean one who thoroughly understands his business, and this is a matter not always properly understood by men who have not had practical shop experience in this particular line.

He must be able to read drawings quickly and thoroughly. He must have a good practical knowledge of molding from the patterns in the foundry, including those to be cast in "green sand," dry sand, and prepared loam; of those molded from patterns, and those "swept up" by sweeps or "strickles," and of the behavior of the various metals in casting, particularly of the different qualities of cast iron, of their liability to distortion, and the varying degrees of shrinkage.

He must have a practical idea of the effect of distortion of castings from patterns of different forms and proportions of solid and cored work.

He should know the correct amount of stock to allow for machining a casting when this is not specified on the drawings, and many other things besides the mere mechanical work of building up the pattern. In this part of the work he must know about the behavior of lumber when made into a pattern; how to so build up his pattern as to secure the greatest rigidity; to so dispose of the pieces of wood composing the pattern that its contraction and

expansion shall not distort the pattern, or the wood be split from the severe strains produced by wet sand, which is always a severe trial for a pattern.

He must have his pattern divided in a proper place to mold easily and without unnecessary time to be spent by the molder; how to so divide his pattern as to render molding easy; when to make the pattern solid to avoid unnecessary expense, and when the job can be swept up in sand or loam and so practically to avoid the expense of a pattern.

All these and many minor points relating to his work he must get by study and experience in order that he may be classed as a skilled pattern maker, and to accomplish this he must be a man of considerable ability to begin with, consequently we must not expect him to be a cheap man.

A great deal of care should be exercised in selecting lumber for use in making patterns, and it will usually be found difficult to obtain really first-class stock of this character. Properly dried and seasoned lumber is not easily found, and even if it is said to have been kiln-dried it may have been left exposed to damp atmosphere afterwards and so absorbed sufficient moisture to make it necessary to keep it stored for quite a time in order to have it fit for use.

It is almost impossible to know just the condition of lumber when it is purchased, either in the rough or planed. It is therefore one of the great conveniences, if not a real necessity, to have a dry-room, heated with a steam coil, so that lumber may be thoroughly "dried out" before being taken into the pattern shop for use.

Care should be taken that this dry-room is not kept at too high a temperature, as such a condition will result in "season checks" in the surface and the ends of the lumber, owing to the too rapid contraction of the surface before the center of the plank, or board, is thoroughly dried. And even after it has been through the dry-room it should not be piled up horizontally, with the flat sides together, but kept on edge, in racks suspended from the overhead timbers of the pattern shop, and in which the lumber is held in position by vertical strips.

Previous to being placed in these racks the lumber should be planed to certain regular thickness from a quarter of an inch to one inch by sixteenths, and from one inch to two inches by eighths. Lumber thicker than two inches should ordinarily be left in the rough until wanted for use, unless there are many large and heavy patterns to be made. This lumber may be piled horizontally with strips laid between the planks every six feet or less, and directly over each other.

As to the kind of lumber to be used, white pine is the most common, although much cherry is used for small patterns and should be used for the smaller loose pieces of pine patterns. In the Western States the author has

seen butternut used to good advantage for patterns, particularly where the pattern has much hand work with the gouge to be done. It cuts easily and smoothly and is stronger than white pine. Mahogany makes a very nice small pattern, but is unnecessarily expensive for any other patterns.

In selecting lumber for patterns care should be taken to get that which has been properly cut from the log, that is, lumber in which the *edge of the grain shows on the side of the board.* Otherwise it will be very liable to warp, no matter how much care has been taken to dry it, or to keep it well protected.

This will be better understood by referring to the engravings. Fig. 201 shows a cross-section of a board cut from the log in a proper manner. Fig. 202 shows the result of cutting the board from near the surface of the log,

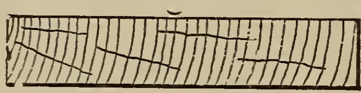


FIG. 201.— The Right Way to cut a Board.

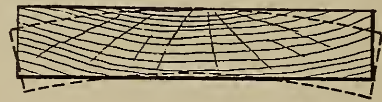


FIG. 202.— The Wrong Way to cut a Board.

making what is technically known as a "siding." The dotted lines show how it will warp. This is due to the fact that the sap, or outer portion of the log, which is of newer growth, is less dense, and will contract more in the process of seasoning.

It is usual to cut up logs in the manner shown in Fig. 203. The boards taken off near the surface of the log are trimmed with an edging saw and should be sold as sidings, for inferior work, but never used as good pattern lumber, unless in a place where they are held and confined so firmly that they cannot warp or distort the pattern. For use as pattern lumber, or for any really good work, the log should be cut up as shown in Fig. 204, which pre-

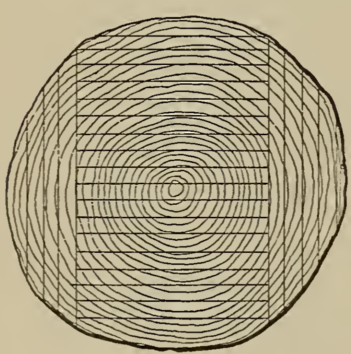


FIG. 203.— The Usual Way of cutting up a Log.

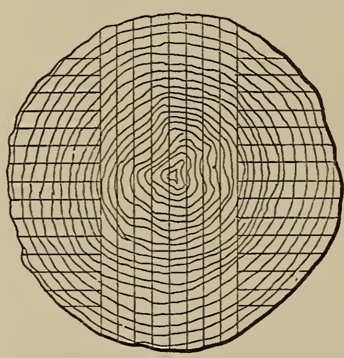


FIG. 204.— The Proper Way of cutting up a Log.

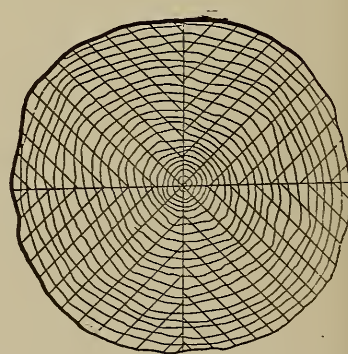


FIG. 205. — Quartering the Log.

serves the grain in a proper direction as nearly as possible, but is not as economical as to the value of the lumber, as it makes a number of quite narrow boards. The furniture manufacturers' term of "quartered oak" refers to a log cut up as shown in Fig. 205, which is the most nearly correct so far as getting all the good lumber possible out of the log.

Pattern lumber is nearly always expensive, no matter where it may be purchased, and much more care should be used in cutting it up in the shop than is usually the case. If this matter is properly considered and thoroughly understood, very little need be wasted. It is well to have a series of shelves, placed conveniently to the circular saws, upon which such scraps as are likely to be useful may be arranged according to their size or shape, so as to be convenient to find when small pieces are wanted.

When a board or plank is cut and a considerable portion of it is left it is customary to stand it up against the wall, or in some convenient corner. This is repeated until a quantity accumulates, the lower ends of the pieces projecting further and further out from the wall, occupying more and more of the floor space, continually "kicked and cussed" until the nuisance becomes unbearable and a cleaning-up process usually results in throwing a good many pieces into the scrap pile.

This might easily be avoided by making a rack, consisting of a piece of 3 x 4 inch scantling, in which are fixed hard wood pins one inch in diameter, placed about six inches apart, and projecting about a foot. This scantling is spiked to the wall in a horizontal position, three to four feet from the floor, with the pins projecting outwardly from it. Pieces of lumber four to eight feet long may be conveniently set up on end between the pins, and any piece wanted may be readily removed without disturbing any of the other pieces. The length of this rack will, of course, depend upon the available space that can be spared for it. One near the circular saws, in addition to the scrap shelves described above, will be found very useful.

One of the best methods of working up the accumulation of small scraps is to have an apprentice make them up into core prints and bosses of all the various sizes in common use, keeping the different sizes in suitable boxes or bins built against the wall. This will not only use up the scraps but will save a good deal of the time of the pattern makers, whose time is too valuable to be spent at this common work.

Another point needs attention in most shops, and that is the too frequent disposition to use first-class lumber for such parts of a pattern as cleats, stop-off pieces, core box backs, the inside framing of a boxed-in pattern, etc., when lumber at half the price would be just as good and cost no more to work up. A considerable saving in lumber bills may be made by attention to these matters, and the standard of good work not lowered for any practical purpose.

Fillets and dowel pins can be much cheaper purchased than made in the shop. A good deal of discussion as to the relative merits of wood and leather fillets has been indulged in. The pattern maker's time will no doubt be saved, and good pattern work be the result of using wood fillets for straight work and leather fillets for curves.

The patented brass dowel pins should be put into all patterns that are to be in continuous use, and the malleable iron rapping and lifting plates, let into the pattern, should be used on all patterns large enough to need them. A stock of these convenient and very necessary articles should always be kept on hand and ready for use.

The system of marking and listing patterns is usually arranged in the drafting room, and the lists furnished to the pattern shop for use and guidance. The plan recommended is to designate each machine built, by a letter of the alphabet, or a combination of two of them, and to indicate the individual patterns of each machine by numbers.

Similar parts of machines of the same type take the same numbers. Thus, if the letter of a machine is B, the patterns will be marked B1, B2, B3 and so on. When a change is made in a pattern, a letter X is added, making the pattern B3 read B3X. If changed a second time it will become B3XX. Further changes would be indicated by one X followed by a number to indicate the number of changes that had been made. For instance, if it had been changed the fourth time it would be marked B3X4. If the swing of a lathe is to be increased or a planer to be widened, by a special order, the new patterns made necessary by this change would be marked with both of the letters indicating the machines, as for instance, the letter K, indicating a 30-inch planer to be widened to 36 inches, the letter being L, the new patterns necessary would be marked K-L, the hyphen being used to indicate that two machines are meant.

Where a machine designation necessitates two letters of the alphabet in consequence of the fact that the letters are exhausted by the variety of machines built, the hyphen is omitted. The letters I O X are omitted as designating letters, as the first two so nearly resemble figures, and the letter X is used to indicate alterations of the patterns.

Pattern letters and figures should be formed with two sharp points on the back, which may be forced into the wood of the pattern and thus hold them securely. The addition of a little thick shellac varnish will hold them more firmly.

These letters and figures may be purchased, or they may be cast in the pattern shop, and as a large number of them are used this will be the more economical way to obtain them. A brass mold in two parts, hinged together, may be made, one part having the letters formed in it, and the other with tapering holes for forming the points on the back of the letters. The metal used is lead, to which is added a small quantity of antimony. A still better alloy is composed of lead 70 parts, antimony and bismuth each 15 parts. The mold is heated over a gas flame, while the metal is melted over a Bunsen burner. Care should be taken not to overheat

either of these alloys. They should be just hot enough to burn a pine stick to a rich brown.

These letters and figures should be of the style known as sharp faced gothic, size three-eighths, or half inch, and are used only for indicating the letter of the machine, the number of pattern and the changes that have been made in it. The letters for the name of the firm, or company, which appear in prominent places on the machine, should be also of the sharp faced gothic style and of a size suitable for the available space. They should be purchased and kept in stock in proper boxes or cases.

Usually three or four sizes of pattern letters and figures will be sufficient. These pattern letters having flat, smooth backs are often fastened to the pattern with small wire brads, which hold them very securely, but are likely to show roughly on the casting unless the job is very carefully done.

A much neater and quicker job may be done by first putting a coat of light shellac on the backs of the letters, then a rather thick coat on the pattern and placing the letters on this before it is dry. In either case a line should be drawn on the pattern for the tops of the letters, and they should all be laid on and the position of each marked before fastening them to the pattern.

The reason for using the sharp gothic style of letters in preference to roman or fancy styles is that there is such a large amount of draft to the sides of the letters that they draw very easily from the sand, and also, that for nearly all classes of castings the plainest letters have a much better appearance than the more ornamental or complicated ones.

Pattern letters and figures should be kept in convenient cases or boxes so as to be securely protected and readily found when wanted. The most convenient form of case is that shown in Fig. 206. This case is 20 inches wide and 28 inches long. The strips around the ends and back are five-eighths inch thick and one and a quarter inches wide; the front is the same thickness and one and three quarter inches wide; the bottom being half an inch thick. The partitions are a quarter of an inch thick, and are "notched together" as in a type case. The letter boxes are 3 x 4¼ inch, except for the letter X, which is 4¼ x 6¼ inch, as many of these are used in marking changes of pattern. The figure boxes are 2 x 3 inch, except that of the figure 6, which also answers for the 9, the box being 3 x 4½ inch. Each case is furnished with two drawer pulls, and the front should be plainly marked with the size of the letters and figures contained in it.

The care of wood fillets, so as not to injure the feather edges, is important, and a safe receptacle should be provided for them. In order to have these articles, as well as leather fillets, brass dowels, wood dowels, rapping plates, etc., properly cared for and arranged in an orderly manner where they can be readily found, the case or cabinet shown in Figs. 207 and 208 is designed

to meet these requirements. The lower part of this case is 59 inches wide, $20\frac{1}{2}$ inches deep and 26 inches high, and contains six of the cases for pattern letters and figures, as shown in Fig. 206, twelve bins for malleable iron rapping

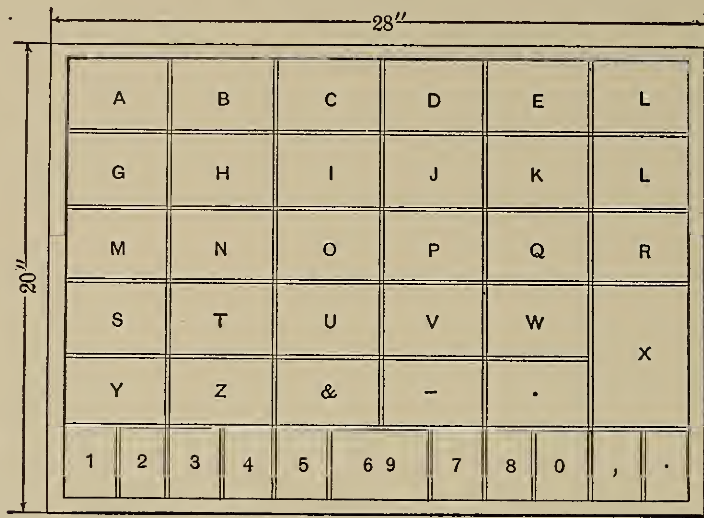
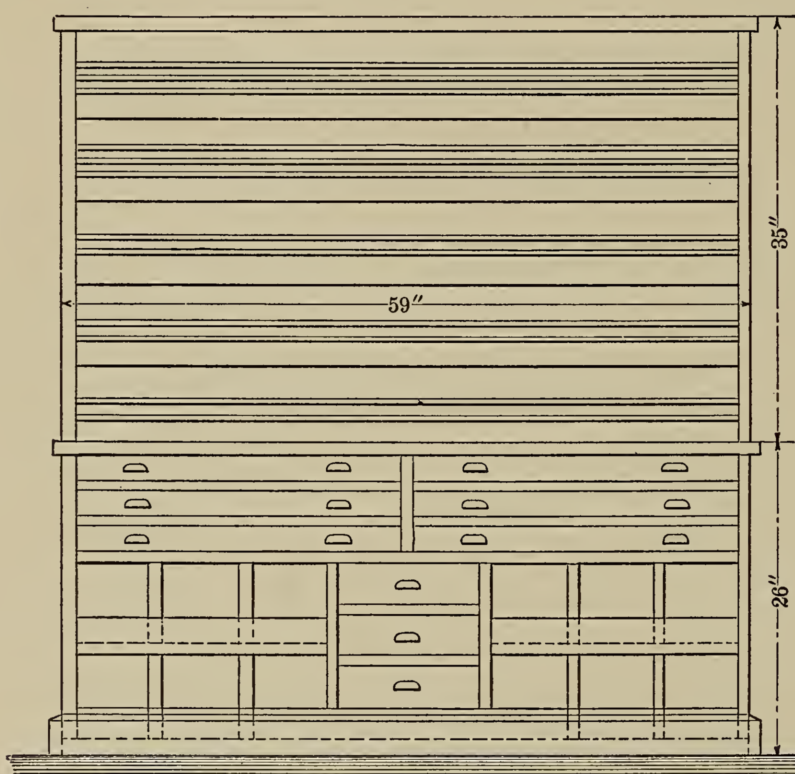


Fig. 206. — Case or Drawer for Pattern Letters and Figures.

plates, and three drawers properly divided for holding brass dowels. The upper part of the case is $8\frac{1}{2}$ inches deep and contains at the top six spaces



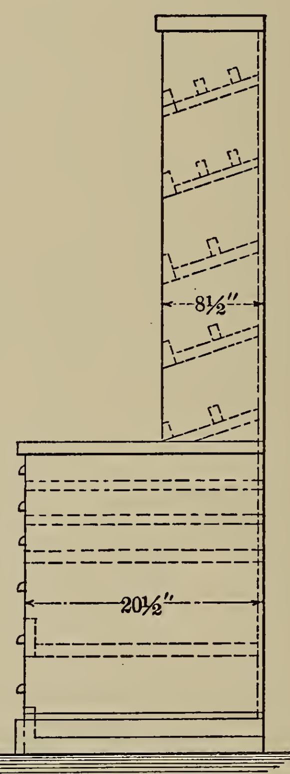


Fig. 207. Fig. 208.

Cabinet for Pattern Letters, Fillets, Dowels, Rapping Plates, etc.

for wood dowels, and beneath these six spaces for wood and leather fillets, both kinds being placed in the same space. The wood fillets being made in four-foot lengths there is ample space for them. This case should be made

of $\frac{7}{8}$-inch pine, with a back $\frac{1}{2}$-inch thick. It will be found a great convenience, as well as a means of saving these articles from waste and injury.

There should be another case with shelves 10 inches wide for holding steel wire brads and wood screws. There should be shelf room enough to show at the front one package of each size that may be used.

Several other packages of the same size may be piled behind the front one as reserve stock. These cases should not be much over five feet high, and arranged against the walls in such a situation as to be most out of the way and yet convenient for the men to get at. They should be built of $\frac{7}{8}$-inch boards. The shelves for any articles as heavy as wood screws, brads, or steel wire nails should be supported by uprights about 30 inches apart.

These cases should have two coats of light shellac varnish. It is always best to have these and all similar fixtures present a neat and clean as well as orderly appearance. It will have a good effect on the workmen and they will take more interest in their work and have more respect for the shop and its management to realize that all these matters relating to their wants are foreseen and properly attended to.

All patterns should be so colored in the varnishing as to show the material of which they are to be cast. To effect this all core prints should be *red*. Patterns for gray iron castings should be *black;* for malleable iron castings, *brown;* for steel castings, *blue;* for brass castings, *yellow;* and for bronze castings, *orange*. These colors may be easily made by the addition of vermilion, lampblack, burnt umber, ultramarine blue or chrome yellow to ordinary shellac varnish.

The colors should be purchased in a dry state and cut with a little alcohol before being added to the varnish. The brown and blue may need to be made a little lighter in color, which may be effected by adding a little dry white lead, cut with alcohol as before. To make the orange, add a little red to the yellow. This method will save a great deal of needless trouble and annoyance from patterns being cast of the wrong material, as colors will always appeal to the eye, and are more easily remembered than any written, printed, or oral directions.

The pattern loft should be so arranged that the groups of shelves are located between the windows, projecting out from the walls so as to form alcoves or passages between them about four feet wide. The best form of shelves will be those supported in the center, near each end, by a vertical standard of wrought iron pipe, set in a cast iron base resting on the floor. Fixed at proper heights on these pipes are cross bars of cast iron, upon which the planks composing the shelves are supported. This leaves the edges of the shelves clear of any obstruction, greatly facilitating the handling of patterns.

A similar arrangement of shelves may be made with wooden vertical

and cross supports, the former being fastened to the floor below and the overhead timbers above. Space should be provided on the floor, or on low supports, or a low platform, for large and heavy patterns, so as to have them in a convenient position for handling. Overhead tracks and trolley hoists may run through the center of the pattern loft for convenience in handling large patterns. They may thus be handled very quickly and economically.

In storing patterns in the pattern loft, those belonging to one machine should be confined to one section or group of shelves as much as possible, the larger ones on the floor or the lower shelves, and the smaller ones on the upper shelves. The name and letter of the machine should be plainly marked on a strip nailed to the front of a shelf four or five feet from the floor. If different colors are used to designate different machines, or types of machines, these signs may be painted the same colors, for convenience in finding such patterns as may be wanted.

The patterns for machines of the same general type should be grouped in one part of the loft, occupying adjacent groups of shelves, if necessary to use those of more than one group. Patterns for castings of malleable iron, steel, brass, and bronze should be kept on one of the shelves in the same group as those for gray iron castings. If special shelves for all the patterns for any one of these materials are kept together there is more liability to mistake in sending the proper ones to the foundry.

The foreman should have a record of the location of all patterns in the pattern loft. The system which will be found to require the least amount of writing and will be the easiest to keep correct from day to day will, no doubt, be the card system. To render this system useful there should be a card for each pattern, and written upon it the letter designating the machine, the number of the pattern, its name, and a list of all loose pieces that should go with it. These cards may be of ordinary cardboard stock, cut 3 x 4 inches and requiring no printing or ruling. The cards representing the patterns of each machine should be grouped, as for instance, an engine lathe, divided into such groups as the bed, headstock, tailstock, carriage, etc., and these groups separated by guide cards, which may be cut 3¼ x 4 inches, with these designations written on the exposed quarter of an inch. Such a guide card will stand more hard usage in constant handling than those cut with the usual small tabs.

These cards should be kept in small, plain drawers, each holding the cards for one machine, the letter and name of which will be marked on its front. As cardboard stock may be had in twelve or more colors and shades, these should be utilized for machines of the same general type, as a matter of convenience.

Or, if desired, cards of different colors may indicate the material used

in the castings. For instance, a gray card for gray iron castings; a brown card for malleable iron castings; a blue card for steel castings; a yellow one for brass castings; and an orange one for bronze castings.

When the patterns are in the pattern loft the cards remain in the usual card drawers. When the patterns are sent to the foundry the cards representing them are moved from their accustomed drawer to one or more large drawers marked "At the Foundry," and are replaced when the patterns are returned. If the dates when these changes are made should be required the cards may be made a little larger, and the dates of the issue and return of the patterns be entered on them with a rubber dating stamp.

By this system the backs of the cards as well as the fronts may be thus used. When all available space has been utilized a new card may be made out. There appears to be only one objection to the use of cards and that can be easily overcome by a reasonable degree of care and attention. This is the liability to put a card in the wrong place, thus causing considerable loss of time to again locate it.

To avoid trouble by the misplacing of cards in the card drawer it is always desirable that only one person shall handle the cards, except in special cases.

When a scheme of different colored cards is used the liability of this error is much lessened. The card system still remains the quickest and least complicated, as well as the most flexible one in use at present.

The time of all employees should be kept on cards in a time recording clock, a day time card being registered for the use of the time keeper, and also on job time cards, each of which represents the time spent by a single employee on a single job, or order number, these aggregating, at the end of the week, the same number of hours as the day time cards.

In addition to these cards there is a material and cost card, kept by the foreman, which contains on one side an account of all time spent on the job by all who have worked on it, and on the other side an account of all material used and properly chargeable to that order number. This card is turned in to the cost clerk when the job has been completed These cards should be 5 x 7 inches and of thick card, ruled and printed similarly to that used for the same purpose in the machine shop departments, except that the articles enumerated will be white pine lumber, cherry lumber, wood screws, wire nails, wood fillets, leather fillets, wood dowels, brass dowels, rapping plates, pattern letters, etc.

The cost of gum shellac, alcohol, glue, dry colors, etc., will be charged upon a percentage plan, the amount used in a month being kept once or twice a year and its relative value to the value of patterns made in the same period being sufficiently accurate for the purpose.

If the system herein described is faithfully, consistently, and carefully carried out it will be found to exercise a good effect upon the employees by interesting them in its methodical and orderly management; it will save much time usually lost in this class of work; it will produce more good work with the same number of men, or the same expense; every man will know his duties and responsibilities; the daily routine of the shop will run smoothly and without friction; and there will be a prevalent air of economy and efficiency in the department that is seldom found where the usual methods, with their wasteful disregard for time and material, are in vogue.

Properly managed, the pattern shop may be one of the best and most economical departments of the entire plant, but carelessly managed it is no small factor in reducing the profits on manufacturing operations.

CHAPTER XXXI

GENERAL EFFICIENCY IN MANUFACTURING OPERATIONS

Changes and improvements. The modern factory. Manufacturing conditions of the present time. Economy a necessity. Arrangement of departments. Character of the work in different departments. Transferring stock. Economy of power. Various systems. Necessary conditions. Location of shafting. Roller bearings. Arrangement of machines. Machines on benches. Efficiency of machines. High speed steel. Design of machines. Design of the cutting tools. Transportation of stock and materials. Shop tracks. Elevators. Trucks. Cars. Overhead trolleys. Distribution of small tools. Overhead carriers. Vertical carriers. Economy of the pay roll. Cheapness not necessarily economy. Classifying employees. Classifying the work. Time accounts. Registering clocks.

EVERYTHING in nature lives, moves, and has its being by a well-defined system of natural laws which govern all animate and inanimate things, and all tend towards the evolution and development of life and matter into an innumerable variety of more complete and perfect forms.

In our world of business, trade, and manufacture, we shall do wisely if we strive to imitate nature in these respects, to the end that whatever plans we may devise, whatever changes we may effect, or whatever processes we may develop, they shall be for the better and more perfect use of the means at our command, and in fact and in truth we may so labor

> "that each to-morrow
> Finds us farther than to-day,"

that each step we take may be a real improvement, a real advancement to better and more perfect conditions of whatever we manage and control.

And in so doing we shall do well to remember that *change* is not always *progress*. That a narrow-minded and short-sighted view of matters, facts, and conditions often lead men, seeing the successful changes effected by their more broad-minded fellows, to endeavor to imitate them by simply making changes. Often to the detriment rather than the betterment of existing conditions.

Hence we should proceed with a well considered and well planned

system, supported alike by theory and experience, since such a system will have all the chances in its favor and consequently always make for success, more or less certain, of course, according to the conditions of the case, while without systematic proceeding to a betterment of conditions will but invite the failure that usually follows.

These conditions and observations are applicable to nearly all positions in life, but in this chapter we propose to consider briefly their relation to the equipment of the modern factory in the effort to decrease its expense and to increase its efficiency in the regular routine work of manufacturing.

As no particular line of goods to be manufactured is taken up the subject will be treated in a general way by referring to such matters as are common to all or nearly all factories whenever possible to so consider the matter.

While the present time is by no means the "day of small things," but on the contrary the day of very large enterprises, it is yet true that the percentage of profits in comparison to the amounts invested and the number of workmen employed are relatively considerably less than formerly. It might be said with truth in almost all manufacturing operations that the percentage of actual waste fifteen years ago was greater than the net profits of to-day. It therefore behooves us to so arrange and conduct manufacturing operations that every item of unnecessary waste may be eliminated, every ounce of material utilized, and every hour of the employees' time expended in useful work, and properly accounted for.

And not only is this true, but also that as every square foot of floor space costs a certain amount of outlay in the interest upon the real estate and buildings, as well as their maintenance and insurance, and the expense for light, heat, and power, we must see to it that every available foot of floor space is occupied and utilized with profit, and every machine kept as constantly employed on profitable work as possible, since every occupied foot of floor space and every working machine must bear, not only its own proportion of these burdens of expense, but also a proportion of those of the unused space and the idle machines.

In laying out and locating the various departments composing the factory, we must first carefully consider what the product is to be and the various operations which will be necessary to its manufacture.

Then we will consider the different classes of machines needed to properly perform these operations. This will give us the needed facts in determining the number of departments required, while the number of machines needed of each class, to properly balance the production, and the space they are to occupy, will determine the floor space to be occupied by each of the different departments.

The character of the work done in each department, from the raw

material to the finished product, will determine the location of the departments in relation to each other, since the material or stock in progress through the factory should be moved on in one continuous course with little or no retrograde movement, as every unnecessary movement adds to the expense of manufacturing, and also interferes with other stock being moved in its onward way towards completion. This is a point too often lost sight of, or its application to existing or future conditions very much underestimated; the result being an unnecessary expense, perhaps small, but continuous.

Much discussion has been indulged in as to the relative merits and economy of driving machines by long lines of shafting belted from the engine; shorter lines driven by electric motors; or motors for driving individual machines.

All of these systems are good in their place and may be used with economical results in the same factory. The special points in favor of each are usually as follows: Heavy machines, requiring considerable power, if placed near the engine, may probably be driven by the system of shafting and belting very economically, while if placed at quite a distance, say one hundred feet or more, it will be more economical to operate them individually by motors; or, if several are located closely together as a group, to drive them from a short line shaft operated by a motor.

We may say, therefore, that it is more economical to transmit power to distances of over one hundred feet by electricity than by shafting and belting. Large machines that are not in nearly constant use should be motor driven, as power is only used when the machine is in actual operation, while in the use of line shafting it must be kept in order, and we must use the power necessary to drive it continuously, even if there is only one machine of the group in operation.

Where machines are driven from a long line shaft, it should be run at sufficient speed to permit the use of pulleys of moderate diameters. Slow running shafts require to be of comparatively large diameter and the pulleys much larger and heavier, consequently the friction is greater and the power must be increased in proportion. If a shaft 3 inches* in diameter is located in the center of the room, driving machines on both sides, its speed being 150 R. P. M. and requiring pulleys from 18 to 36 inches in diameter to drive the machines, it will be found much more economical to replace it by two shafts of 2 inches diameter, and running 300 R. P. M., on each side of the room and carrying pulleys from 9 to 18 inches in diameter. The aggregate weights of the two shafts and their pulleys will be much less than that of the

*Regular sizes of shafting are "on the odd sixteenth," that is $2\frac{15}{16}$, etc. The even inch is here given for convenience only.

one large shaft, the belts may be shorter, narrower, and lighter, and consequently the power much less.

The weights upon line shafts will be materially reduced by the use of the pressed steel pulleys. This will apply to all pulleys of ten inches and larger. A still further economy will result by driving each of these two shafts by a motor. This would also permit the stopping of either of them in case of an accident, without interfering with the other.

In cases where the factory is of several floors and the power transmitted by vertical belts, the driven pulleys should be of the friction clutch form for the purpose of throwing out any one shaft without stopping any of the others. All shafting of two inches or over should be provided with roller bearings, preference being given to those of the flexible type. An automatic system of lubrication for shafting has become a necessity and will be a great saving of power. The simple form of a reservoir beneath the bearing, from which the oil is drawn through a piece of felt, and returned by way of grooves at each end of the box, is an excellent and economical device, although there are many others equally as efficient.

The location and relative arrangement of machines is a matter of much importance. If the department contains a variety of quite small and medium sized machines, the smaller ones may be well arranged on benches along the walls where the light is always good. The bench may be very useful for holding stock and material in process of manufacture. This method will leave the central portion of the room for larger machines set up on the floor, and still leave ample passageways in a building of the usual width, say forty feet. This would allow, on each side, a bench two feet wide, another two feet for the operator, behind whom would be a passageway six feet wide, and still leave a 20-foot space in the center for larger machines, and a central space for a passageway, car track, etc.

Frequently machines set on wall benches may be driven from a very light shaft located only three or four feet above the bench, thus eliminating about 50 per cent of the lengths of the machine-driving belts, and still leaving them long enough for good service. Machines of the same general type and doing the same class of work, or consecutive operations upon it, should be grouped together, for convenience in handling the stock in its continuous progress.

The degree of efficiency of machines operating on cutting metals may be very materially increased by careful experiment and study of speeds, the best qualities of tool steel for the particular purpose, and the form of the tools. It is not good economy to force cutting speeds to the highest limit, even with the best high-speed steel. The point to be determined is the highest economical speed for the metal operated upon, the form of the piece being

made, and the particular machine used for the work. And however much we may experiment in this matter we shall probably never arrive at any fixed rule of say so many feet per minute for machine steel, so many for cast iron, steel, brass, bronze, etc.

Much will depend on the design of the machine, the manner of holding the tool, as well as the method of holding the piece to be machined; the whole combining to give rigidity and prevent vibration, both laterally and in the direction of motion, as even the slightest vibration of tool or work will reduce the possible cutting speed.

Neither shall we arrive at any fixed angle of side clearance or top rake for a cutting tool, inasmuch as that it depends to a considerable extent on the form and rigidity of the machine used, the nature of the cut, etc.

The operations of milling, drilling, and tapping, as well as nearly all similar operations, will require the same observation and experiment to arrive at the best, most efficient, and economical speeds, in view of the individual conditions governing the work.

Where the work is heavy enough to warrant it, there should be shop tracks, let in flush with the floor level, upon which should run shop cars of such dimensions and weights as their loads may demand, and of such form as may be necessary to adapt them to the particular form and character of the stock and material to be handled. For this purpose they may be provided with racks, shelves, trays, boxes, crates, etc., as may be needed; these accessories being readily removable so that others may be substituted. In a factory of several floors, the elevators connecting them should be provided with similar tracks, so that cars may be conveniently run upon them and taken to any desired floor.

There should be a number of switches, at least one to each line of tracks, where cars may pass each other, so as to avoid lost time. At one end of the room a cross track may be laid, forming connections with the principal tracks by curves, or by turntables at the intersections.

When the character of the stock and material to be moved is not of sufficient weight to require tracks, the cars may be replaced by trucks of proper dimensions, their wheels being provided with rubber tires to avoid jar and noise. Both of these methods of transportation may be advisable, say a track through the center of the rooms and trucks serving the machines at the sides. The accessories for trucks and cars should, of course, be interchangeable.

Where there are no belts or other obstructions in the way, overhead trolleys may be arranged for transporting light stock and materials, with economy. These trolleys may run upon overhead I-beams, or beams of special form adapted to their use. These may also be used on the elevators

and connect with the overhead system to good advantage. Switches are as readily used in this system as in floor tracks, but the same degree of adaptability of racks, boxes, or other special accessories will not be realized.

Particular attention has been given to this question of transportation as it is a matter where a good deal of useless expense may be saved if it is properly understood, rightly considered, and carefully planned and arranged.

By a perfectly arranged system of transportation much time of the employees at the machines may be saved, as well as some of the confusion incident to the employees going after their work or delivering what they have completed, as is sometimes the case.

Proper arrangements should be made for conveying small tools to and from the tool room. It is a most unnecessary waste of time to permit operatives to leave their machines to grind tools, or to go to the tool room to exchange them. Overhead carriers similar to the cash carriers in large stores may be utilized with considerable saving of time over the employment of a sufficient number of boys, as a sharp tool may be quickly sent to the machine and the dull one taken out and returned without the operator leaving the machine.

Should there be only one tool room to several floors, a vertical carrier may connect them with the overhead carriers, requiring only the services of a boy on each floor. This vertical carrier is simply a belt or chain running over a pulley at the basement and another at the top floor, and being provided with small trays, or buckets, which should be painted a different color for each floor, so that their contents may readily reach their proper destination. A speaking tube should connect the different floors.

One of the most important matters to be kept constantly in mind in the management of a factory is the pay roll; and in keeping this at a minimum, let us not forget that cheapness is not necessarily economy. And that cheap employees are often like cheap goods, ultimately expensive. Shop men of experience will all remember instances where the work done by a good man at a high rate actually cost less money than if done by an inferior man at half the pay, while the shop burden of expense was less on account of quicker work.

The one important point is to keep each class of employees on the work where they are the most profitable to the establishment, and this proposition involves conditions that can only be met by years of practical experience.

Again, employees should, as far as possible, be kept on the same class of work, as they thereby attain not only a great degree of speed, but accuracy in doing their work, which is not possible if they are changed from one kind of work to another. This is one of the most certain methods of increasing their efficiency.

A watchful care must be exercised over all time accounts, particularly of such employees as may be called upon to labor on different classes of work, or on different orders, to the end that no part of their time is charged to some general account when it is possible to assign it to a special one.

All employees should register their time on day time cards in a recording time clock, for the use of the time keeper in making up the pay roll, and again on job time cards (a separate one for each job, or order number), for the use of the cost clerk. These latter must, of course, aggregate the time indicated on the day time cards. They should be made out by the department foreman, who should see that they are properly recorded, and he should approve them with his O. K. stamp at the end of the week before they go to the cost clerk.

Within the limits of this chapter it is only possible to refer briefly to some of the more salient points in factory economy and efficiency, but it is hoped that a few hints given may nevertheless prove useful and practical to those having charge of these matters, and that if they are conscientiously worked out upon the lines herein suggested and those more minutely described in the previous chapters, with a watchful care to their adaptation to the prevailing local conditions, and to their success in actual practice day by day, the author is assured that their success will be amply demonstrated in other cases, as he has often found in his own experience under similar conditions and circumstances.

CHAPTER XXXII

MACHINE SHOP MUTUAL AID ASSOCIATION

The necessity of such an organization. Sick benefits. The lodge method. Death claims. Accidents and sickness. Economy of the proposed system. The general plan. The physician. Officers of the association and their duties. Business meetings. Weekly dues. Classification of members. Table of classes, dues, and treasury receipts. Rate of weekly benefits. Suspensions of the payment of dues. Simplicity of the plan.

FIRST AID TO INJURED EMPLOYEES

Necessity and value of such an emergency department. Under supervision of the physician of the Mutual Aid Association. His duty as an inspector. Liability to injury. Necessity of prompt attention. A case in point. Simplicity of the work. Emergency room, its work and its equipment. Medicine cabinet. Instruments. Portable case. Electric call bell. First cost. Economy of maintenance in proportion to benefits conferred.

MACHINE SHOP READING ROOM

Shop conditions. Necessity of a shop reading room. Its value to both employer and the employees. The class of reading matter desirable. Technical publications. The employers' opportunity. The room necessary. Politics to be avoided. Circulating technical publications. Lectures and shop talks on pertinent subjects. Lessons in mechanical drawing and plane geometry. The spirit of the unity of interests.

MACHINE SHOP DINING ROOM

Good reasons for its organization. The progressive manufacturer. The room necessary. Cold lunches. Practical utility. A noonday restaurant. Plan of management. The Menu. Kitchen equipment. Practical advantages. Expenses of maintenance.

Machine Shop Mutual Aid Association

The fact that in the lives of all employees of shops and factories, in common with other people, come periods of illness and times of accidental injury, incapacitating them from following their usual avocations, and coming unexpectedly, as they do, often find them unprepared financially for such a loss of revenue and the additional expenses incident thereto, is the strong argument of the insurance companies' agents in seeking that class of their

business which promises "sick benefits" and assistance in cases of accident. There is no doubt that such insurance often does much good in assisting the person during the time when he is incapacitated from performing his customary work.

But, that the usual methods of insuring in this manner are the most economical is certainly an open question, and many there are who do not believe that it is. Again, the form of mutual insurance in lodges, many of which form a larger superior body, or grand lodge, and several of these again forming a supreme body, while they may be an improvement in some respects, do not seem to meet all the requirements, as may be readily seen from the fact that once in a while we hear of these organizations going to pieces, and the persons who have faithfully paid in their money year after year find it swept out of existence so far as their interests are concerned. While it is true that this form concerns more particularly the death claims, yet it does also affect those for sickness or accidental injuries as well. It is true, however, that this plan is more economical to administer than the first plan, yet it still has too great administrative expenses, which may be avoided by the plan here proposed. It also has the disadvantage that in some parts of a large field of operations more money will be required for claims than in other parts, and consequently the healthier portions must be drawn upon to make up the deficiencies of the less favored localities.

So far as financial assistance in cases of accident is concerned, it would seem best that each organization, as the employees of one shop or manufactory, for instance, should stand alone, and by mutual assistance realize the greatest measure of benefit with the least possible outlay for administrative expenses. There is no good reason why the same should not hold good in the cases of sickness. By this plan there will be a much greater degree of confidence among the subscribers or members, inasmuch as they all usually know each other, elect their own officers, and fix the dues, benefits, and general policy of the organization. Abundant instances of the success of such an organization are at hand.

The plan here recommended is one, with a few modifications, with which the author was connected, and which succeeded beyond the expectations of its organizers, for many years. Briefly the plan is this. To organize a Mutual Aid Association, confined to the employees, male and female, of one company, firm, or corporation, who subscribe to its constitution and by-laws, agreeing to pay into its treasury stated amounts in proportion to their weekly pay, as dues or premiums, in accordance therewith. In consideration of these payments they are to receive, when ill or disabled by injuries, a certain proportion of their weekly pay, and also the attendance of a physician selected and paid by the association, if they desire his services.

The officers are a president, vice-president, secretary, and treasurer; also an auditing committee of three members. The dues of the secretary and treasurer are remitted in consideration of their services. No salaries are paid except to the physician, who is not a member of the society. In small societies one person may fill both offices of secretary and treasurer. Where there are female members they should be represented in the board of officers. Business meetings are held once in three months, at which the officers report the business done during the preceding quarter. The proprietors of the concern will usually furnish a room in which the meetings may be held.

The dues per week are one half of one per cent of the weekly pay, as being convenient to calculate. Thus each member pays a half cent for each dollar of weekly pay. If the pay is not in even dollars the next even dollar above the amount is taken as a basis in fixing the amount of dues. For convenience, the dues are collected once in four weeks (not monthly). The benefit paid after the first week of illness or injury is one half the weekly pay, reckoning fractions of a dollar of pay the same as in fixing the amount of dues.

For a society of five hundred members a physician will usually contract to attend such members as desire his services for $250 per year.

From the foregoing facts we may see that in a shop with five hundred employees, divided into classes as to amount of pay, the amounts collected will be as shown in the following table:

EMPLOYEES IN EACH CLASS.	WEEKLY PAY.	WEEKLY DUES.	TOTAL WEEKLY DUES.	COLLECTED EVERY FOUR WEEKS.
25	$ 6.00	3 cents.	$0.75	$ 3.00
50	7.00	3½ "	1.75	7.00
75	8.00	4 "	3.00	12.00
75	9.00	4½ "	3.37½	13.50
100	10.00	5 "	5.00	20.00
100	12.00	6 "	6.00	24.00
50	15.00	7½ "	3.75	15.00
25	18.00	9 "	2.25	9.00
500			$25.87½	$103.50

This gives us $25.87 per week for the payment of claims. Experience proves that there will seldom be as many as three persons in the five hundred members receiving aid at any one time, and the number is usually considerably less.

The amount of the aid or benefit paid being one half the weekly pay, it will be found upon calculation to average $5.62 per week, or $16.86 for three beneficiaries, which will leave a liberal balance for unusual calls, as well as for the payment of a physician, this balance being $218.00.

Whenever the funds accumulate in the treasury to an amount over $300, the collection of all dues ceases until the amount is reduced to that figure.

It will be seen that the plan and its administration is very simple, and in this, in a great measure, lies its success, while the mutual interest of all its members insures its smooth working and efficiency. Upon organizing such a society each member pays as an entrance fee the first four weeks' dues, and benefits commence as soon as occasion demands.

First Aid to Injured Employees

Still another adjunct to the organization of the modern machine shop that is productive of much good is the Emergency Room, wherein the accidentally injured employee may be quickly and properly treated. Where there exists a Mutual Aid Association, as suggested in the beginning of this chapter, this department will naturally come under the supervision of the physician of that association, who will instruct a suitable attendant in the duties of his position. He may also, at stated times, inspect the shops to ascertain if proper safeguards exist and are in proper use in and about the shops, such, for instance, as that all projecting set screws in collars and couplings on shafts are properly protected; that gears are provided with suitable coverings; that saws are properly covered with guards; that rapidly revolving cutters are guarded by mica or glass; that the eyes of the men working where they are liable to injury from chips or flying bits of metal are protected by goggles; that they are also used as a protection in the grinding room where particles of emery are liable to injure them. These and many of similar nature must be looked after, yet when all this is attended to faithfully men are still liable to accidental injury, and for these emergencies proper facilities for rendering first aid to the injured are of very great importance, as it not infrequently occurs that the harm done by waiting for the arrival of a physician or surgeon may be of greater consequence than the original injury. This is particularly the case where there is much loss of blood, as it is also in cases of sudden sickness as cholera morbus and similar affections. Such cases are occurring every day even in cities where a physician may be located within a block or two but may at the moment be absent from his office. The author remembers a case in which the workman died before medical aid could be obtained, although there were three physicians having offices within a radius of from fifty to two hundred yards of the shop, but all, unfortunately, absent at the time.

The work to be performed by such an Emergency Department is usually of a very simple nature. The equipment of such a room will naturally include a cot bed, a stretcher, a suitable medicine cabinet, and a portable case that may be easily carried to an injured man in any part of the works. There should be in this room a stationary wash bowl supplied with hot and cold

water, and a plentiful supply of towels, bandages, and the usual surgeons' dressings, such as iodoform gauze, absorbent cotton, adhesive plaster, isinglass plaster, powdered iodoform, etc.

The medicine cabinet should contain such convenient remedies as tincture of arnica, jamaica ginger, camphorated tincture of opium (paregoric), chloroform, camphor, peppermint, aromatic spirits of ammonia (a restorative), whiskey, witch hazel, vaseline, a liniment of equal parts of chloroform and aconite, another of the same with one half the quantity of sweet oil added, a diarrhœa remedy composed of equal parts of tincture of opium, spirits of camphor, and tincture of rhubarb, dose 40 drops, and such other remedies as the supervising physician may direct.

There should also be at hand a pair of straight and a pair of curved scissors, surgeons' needles and silk or gut, two medicine glasses, a four-ounce graduate, one each table, dessert, and tea spoons, two tumblers, sugar, bicarbonate of soda, chloride of mercury tablets for making an antiseptic solution for cleansing wounds, a white enameled ware basin or bowl for holding the same, a tourniquet for arresting the flow of blood, a pair of small forceps, and such other instruments and appliances as directed by the physician.

The portable case which the attendant may carry with him to any part of the works should contain only such articles as are likely to be needed in dressing a wound, stopping the flow of blood from a severed artery, relieving the convulsive cramps of cholera morbus and similar sudden affections, or restoring a patient liable to faint from loss of blood.

There should be an electric call bell in the Emergency Room, connecting with push buttons in each department of the plant, by means of which the attendant may be quickly called to any part of the works. On responding to such calls he will always carry the portable case above described. These cases may be purchased complete, fitted with such appliances and medicines as may be desired from the wholesale drug and supply houses.

Aside from the first cost of fitting up and purchasing the proper appliances for such a room, the cost of its maintenance is principally in the wages of the attendant, which may be very moderate in amount and whose instruction may be a part of the duty of the contract physician of the Mutual Aid Association. It may frequently happen that a young man studying medicine under this physician will give his services for the use of the Emergency Room as a study, and the value of the practice he may obtain in attending the men of the establishment, as this will be of a nature to add much to his practical knowledge in the profession he has chosen.

In proportion to the benefits conferred, the expense of maintaining such a department is nominal, and should not deter any progressive manufacturer from organizing it. Many cases of sudden sickness may be relieved by very

simple remedies if taken in time, and the man returned to duty in an hour or two that might otherwise require days and weeks for recovery. Many cases of accidental injury may be saved from fatal results by prompt attention, or from prolonged suffering by the timely aid of the emergency attendant. Once such a department is organized and its good effects and uniform benefits observed and appreciated, it will become a very popular adjunct to the manufacturing establishment, and one that owner and employee alike will feel cannot be dispensed with. Such has been the experience of manufacturers who have organized such a service, and such will probably be that of any whose care and consideration for their employees induces them to establish it in their shops.

The Machine Shop Reading Room

In discussing the question of costs in the machine shop in the previous chapters reference has been made to the fact that high salaried workmen will frequently do a given piece of work for less actual cost for labor than the same work would be done by a man earning only one half the daily wages. The matter was followed up with the additional advantage of employing good workmen by the fact that the more highly paid man occupied only the same space, used the same machine, and as he did his work in less than half the time the burden of shop expense was less than half that of the work done by his less experienced shopmate.

The natural inference to be drawn from these conditions, which may be met with every day in the machine shop and manufacturing plant, is that it pays to have skilful workmen.

In these days of advanced thought on mechanical as well as other subjects, it is one of the necessities of the times that if a workman is to get to the head of his class in a proper understanding of his work and the conditions under which he labors and by which he is surrounded, he must make an effort to become better educated, not only in his chosen line but in other branches related to it. This education cannot always be obtained in schools, since there are to-day in the shops many men who have not enjoyed the advantages of a technical education and there are likely to be many of the same class in the future.

Again, while the advantages gained by a technical training in the excellent schools of the present day are many, there are other and important advantages that should not be neglected, even by the technical graduate. These are the advantages gained by the systematic reading and study of technical and trade publications. They are for the most part filled with not only the newest but the most practical articles, descriptions, and essays that it is possible for their editors to obtain by a liberal outlay of money. They are not the com-

pilations of what was the thought of years ago, but emanate from the brain and practical experience of men active in mechanical affairs, and selected for their practical utility by editors with a practical knowledge of the subjects of which they treat. They are, therefore, rich in theory, but richer still in live up-to-date practice.

While the bright mechanic of to-day usually subscribes to one or more of these publications relating particularly to his own trade or specialty, this is not sufficient to give him the broad-minded view of conditions and the experiences of others that he should have. Still, the expense necessary to obtain a number of these often will deter him from gratifying his desire for a broader outlook that their possession might give him.

For these reasons it would seem to be not only a matter of much benefit to the employees, but in an indirect though perfectly practical way an advantage to the employer, to institute a Reading Room for the employees where they may have all the advantages to be desired by a free opportunity to read and study the best there is published in their particular lines. It is true, as everyone will doubtless admit, that one's reading has much influence on one's thoughts and opinions. Surely the same may be said in respect to its influence upon one's everyday work, and the more liberal are the conditions in this respect the more will be the actual benefit both to employee and employer.

Every employer has it in his power to do something in this respect for the men that he employs. And the slight expense which he thus undergoes will have many and far-reaching effects. He will not only have better men, so far as their work is concerned, but better men in their knowledge of all that relates to it. He will have men more loyal to his interests; better satisfied with their positions and with more pride in the fact that they are a part of an establishment managed upon a scale of intelligent liberality and consideration of the circumstances and conditions under which they labor. And the spirit of loyalty thus engendered will go far towards the success of the establishment in so far as it lies with the employees.

In organizing a Shop Reading Room the first requisite is a good, light, clean room, in the office building if one there is available. It should be furnished comfortably but plainly, and with such furniture as will make it a pleasant place for the men to congregate. The room should be open during the noon hour and for two or three hours in the evening.

As to the class of literature to be provided, it may be said that it should not be confined to technical publications, but may well include the best local papers, excluding, of course, those of a sensational kind, which do vastly more harm than good among all classes of the workingmen of to-day. Good magazines of general literature should be on hand, as well as books of history,

biography, and technical works bearing upon the industries in which the men are engaged in their daily work.

The question of politics should be eliminated as far as it is possible to do so, both by the choice of literary matter and the discouragement of discussions of this nature. This should be particularly the case in view of the fact that there might be among the men a suspicion that the employer was endeavoring to impress *his* political opinions and prejudices upon them.

The expense of providing all the literature for a shop of two hundred men ought not to cost over eight or ten dollars per month. Many publishers will furnish their publications free of expense if their use is explained to them, and in various other ways may good and valuable periodicals and books be acquired for the use of the men.

There is another important use of the material in the Reading Room. This is that of circulating the books and periodicals among the employees for home reading, thus giving them free the advantages of reading matter that might not otherwise come in their way. It will generally be found that there are men in the shop who will act as librarian of the Reading Room, under the direction of the firm. A man of studious nature will naturally enjoy such a position and by various plans and his own personal interest in the scheme will do much to insure its success and to make it popular with the employees, and thus foster a fraternal spirit between shopmates which will be still further cemented by their common interest in the Mutual Aid Association described at the commencement of this chapter.

Carrying out the idea of education of employees still further, there may be instituted among the men during the winter months a series of shop talks or lectures on mechanical and kindred subjects, not only by public-spirited citizens outside the shop, but particularly by the owners and officers of the establishment, that will go far towards the enjoyment and practical education of the men, but also, what is of considerable practical importance, foster a spirit of interest, not to say common interest, between the owners and their workmen, that will bear fruit in increased loyalty and to the best good of all. These lectures may also be profitable when concerned with subjects of public good and town improvement, whereby the workmen may gain enlarged views of the duties of good citizenship and many other important duties not directly connected with the shop.

Another subject which will commend itself to the consideration of the younger mechanics will be a course of lessons in mechanical drawing and the use of plane geometry. These subjects are of great practical utility to young mechanics and at the present time every young man who aspires to become a first-class machinist is expected to be more or less proficient in them. Such lessons can usually be given by the chief draftsman or one of those working

under him who possesses an aptitude for this kind of work. While he is imparting to the members of a class the information that is always sought by the ambitious young mechanic, he is receiving from the work much of benefit to himself. Still further, the effect will be to foster a certain feeling of interest between the drafting room and the machine shop, which in many shops is not as strong as it should be, but which is always necessary and valuable to the successful running of the establishment.

This same spirit of unity of interest among the men of different departments is a very desirable condition, and the wise manager or superintendent will always aid and encourage it in every legitimate manner. There is no one condition more conducive to the success of a manufacturing establishment than that all, from the owners to the youngest employee, shall realize and work for the common and mutual interest of all concerned, and no one condition that will go as far toward the avoidance of labor difficulties and the elimination of all disagreeable and adverse conditions as a feeling of mutual respect between owners and employees, and between one class of employees and another, and a feeling that in case of any real difference of opinion as to shop conditions, each side is perfectly willing to listen to the reasonable arguments and explanations of the other in a perfectly friendly and mutually interested spirit.

The Machine Shop Dining Room

The sharp competition in all lines of manufacture and the strife for supremacy in all that goes to make up an efficiently productive manufacturing plant has not lessened the effort to improve the conditions of the workmen and to render their surroundings more pleasant and congenial. On the contrary, it would seem that those manufacturers of a broad-minded comprehension of the necessities and conditions of the case, and with a liberal desire to do the fair and proper thing by the employees who serve them faithfully, have taken up voluntarily many of these problems and, much to their credit, be it said, perfected wise and beneficent plans to this end.

Among these is the Shop Dining Room, wherein the men may congregate to eat their lunches at noon, or to purchase at cost prices such lunches as they desire.

This room should be sufficiently large to easily accommodate all the employees, who may sit upon fixed seats on each side of fixed tables, the construction of both being of a plain description such as any ordinary carpenter may build, and covered with white oilcloth.

In many cities and even in smaller communities it is the custom of a large majority of the workmen to eat cold lunches which have not been improved by lying in a lunch box five or six hours, and drinking coffee that has

been made for that length of time, corked up in a bottle and then "warmed over" by setting the bottle on a hot steam pipe or suspending it with a string in the hot water in which the men are to wash up before they eat their lunch.

To these men the privilege of assembling in a clean dining room where a cup of hot coffee, freshly made, is served at the employer's expense is one which all shop men would enjoy. To effect this is a comparatively simple matter for any shop owner, and requires but a moderate outlay as to first cost and for maintenance, as the dishes necessary may be of a very plain and inexpensive quality and the coffee may be made by one of the men who quits his regular work a half hour before the meal hour for that purpose.

Some progressive firms have gone much further than this in organizing the Shop Dining Room and made it practically a noonday restaurant wherein the employees may get a warm lunch of well cooked and wholesome food at exactly cost price, which of course is much more reasonable than can be obtained at a restaurant which must be run for the profit there is in it.

In one such Shop Dining Room the firm have completed its arrangements until it would seem that it is well-nigh perfection in this respect. The men may be divided in squads of ten and one of their number detailed as a waiter for the week or two as arranged, another taking his place at the end of that term. This waiter is provided with a tray and an apron with three pockets, in which he carries hard rubber meal checks of different colors, each color representing a different denomination of one, two, and five cents. These meal checks are kept by the time clerk and sold to the men in lots of from twenty-five cents to one dollar.

To show the inexpensiveness of the dishes that may be served the following menu is given, and vouched for as being entirely practical and possible in any ordinary city.

Pea Soup	3 cents	Mince Pie	4 cents
Roast Lamb	5 cents	Coffee	2 cents
Stewed Tomatoes	2 cents	Tea	2 cents
Mashed Potatoes	2 cents	Milk	2 cents
Ham Sandwich	3 cents	Ginger Snaps, 5 for	1 cent
Cheese Sandwich	3 cents	Crackers, 5 for	1 cent
Bread Pudding	3 cents		

Among other dishes served may be included sausages, hamburg steak, pork and beans, corn, cabbage, sauerkraut, turnips, parsnips, butter, bread, etc.

At each meal the menu for the following day is displayed and each man given a chance to select what he desires for the next day's dinner, which the waiter enters upon a printed blank used for the purpose, which he gives to the cook, who may thus know what to prepare for the next day, so as to avoid

unnecessary waste. The waiters assemble in the dining room fifteen minutes before the men quit work, don their aprons, line up and each in turn calls off his order from the order card and pays for the same in the checks above mentioned. By the time the men arrive the food is on the table and ready for them.

By promptness in this matter they are all easily served even if the lunch time is for only a half hour.

The kitchen equipment for a shop of moderate size need not be elaborate, and one cook and one assistant can easily prepare food for two hundred men, although at meal time he will need two extra men to assist in issuing the food to the waiters.

There is no doubt that such a dining room would be of great advantage to the workmen of any establishment, and that by its organization and maintenance the physical well-being of the men would be very much improved, the mutual good feeling between the owners and their employees fostered and strengthened, and many of the ills resulting from the cold lunch practice in the shop would disappear.

The only expense of maintenance to the firm is the pay of the cook and his assistant and the fuel needed for cooking. To this must be added, however, the cost of broken dishes and similar incidentals. This, of course, does not include the first cost of installation, or an amount representing the rent of the necessary rooms.

CHAPTER XXXIII

INCREASING THE EFFICIENCY OF MACHINES

The question of efficiency. Classification of betterment work. Preparatory analysis. Classification of machine work. Planing. Shaping. Milling. Heavy turning. Medium class of turning. Gear and rack cutting. Drilling and boring. Grinding. Improving the design of machines. Increasing the efficiency of a vertical boring mill. Better tools. Arrangement of machines. A specific example of re-arrangement. Transportation facilities. Beneficial results. Systematic planning.

The question of efficiency is one of the most important with which the engineer has to deal. In the plans which he may devise for the arrangement and the erection of manufacturing buildings; in providing these buildings with power, heating, lighting, and transportation equipment; in inventing or purchasing the machinery best adapted for turning out the proposed product; and in employing the best workmen that can be found to operate these machines, — his plans will end in partial or complete failure if he shall not have kept in mind continually as his aim and objective the condition of realizing the highest efficiency of every piece of machinery and of every individual man of the plant.

It is a positive fact, often proved by such specialists as the mechanical engineer, the production engineer, the standardizing and the efficiency engineers, that in a large majority of manufacturing plants at the present time the actual efficiency of the entire plant will fall below 50 per cent. This being the case in a large number of plants, it is our duty to ascertain the reasons for these conditions and to work out such plans for the betterment of these as may promise to produce the greatest benefit in the most economical manner.

In considering the problem involved in this betterment work we may properly divide it into classes, which for logical consideration will be as follows:

First. The selection and adaptability of the machines used for the purposes for which they are intended.

Second. The improving or re-building of existing machines so as to increase their range of work and efficiency.

Third. The arrangement of machines with relation to each other for efficient operation.

Fourth. The transportation facilities for bringing the material to the machines, and for removing that which has been operated upon.

Fifth. An accurate record of the hours of running time, and the idle time, of the machines.

These several propositions will be taken up in order and the comments and explanations in relation to them will embody the results of the engineering experience, practice, and development of the present day.

Primarily we will consider the extent and the nature of the work to be done, before we can make any calculation on the classes or the numbers of machines that may be necessary. This will be the work of an expert mechanical engineer, who must analyze the product to be turned out as to the form and weight of the machine parts, the material of which they are to be made, and the machine operations necessary to prepare them for assembling them into the complete machines. This will be a long and arduous, as well as complex, task and one in which every new case will present differing conditions and circumstances which will call for much ability and good judgment of technical and manufacturing conditions. For these reasons it is manifestly impossible to lay down more than a few general observations upon this important question.

The following suggestions are given as representing the best machine shop practice in providing machines for the various classes of the work. The general class of work is given first, then the class of machines upon which the work is most efficiently and economically done.

First. Planing. Planers are used for long cuts on heavy work. The product may be a single piece of considerable size and weight, and proportionately long. Or, a number of like pieces which may be placed end to end on a long planer table and cuts run over them all.

Second. Shaping. The shaper is equally well adapted for work requiring shorter cuts, and work within its limits can usually be done more expeditiously than on a planer, particularly such work as is not adapted to be done with a single tool.

Third. Milling. Of milling machines there are two general types, horizontal and vertical. The horizontal machines may be of the plain or universal forms. The vertical may have one or two spindles. There are also several kinds of special machines adapted to a certain range of special purposes. The milling machine in its various forms is adapted to a very large variety of work, particularly short cuts of irregular cross section. The vertical type is now used with a high degree of efficiency and accuracy on many kinds of work that was not formerly thought possible. The comparatively recent appreciation of the efficiency of the inserted tooth cutter has much to do with this fact as well as the added usefulness and adapta-

bility of the milling machine for many new uses. A form of large machine of somewhat similar construction as a planer makes wide and heavy cuts, frequently exceeding a planer in efficiency and accuracy.

Fourth. Heavy Turning. For turning very large and heavy work such as rolling mill work, crank shafts, etc., the heavy triple geared lathes are best adapted. Special lathes are built for such work as roll turning, locomotive driving wheels, and similar work. Recently the vertical boring mill has been much used on many circular castings formerly machined on the face plate of a lathe, and with much greater economy. Several boring and turning tools are used simultaneously, and the work is more advantageously handled on a horizontal table than a vertical face plate.

Fifth. Medium Class of Turning. This class of work in the form of shafts, etc., is very economically handled on the so-called "Rapid Reduction Lathes," the "Lo-swing Lathe," and similar highly developed types of the engine lathe, although much of this work is still done on the ordinary type of engine lathe, with various labor-saving attachments, gauges, and the like.

Sixth. Small Turned Cylindrical and Flat Work. This class, including a great variety of small shafts, studs, pins, collars, flanges, stuffing box glands, gear blanks, and similar machine parts are economically made in hand or automatic turret lathes, automatic screw machines, and similarly designed special machines, as well as engine lathes having special attachments for doing this class of work.

Seventh. Gear and Rack Cutting. This work is rapidly becoming of more importance in machines of modern design; so much so that there are many shops organized for the sole purpose of doing this class of work. In manufacturing concerns doing their own gear cutting automatic gear cutters, gear shapers, and gear planers are almost exclusively used, while hobbing machines for worm gears have an adjustable power feed device whereby very accurate work is turned out. Spiral gears, now so much used, are very generally cut on a universal milling machine, of which there are several of exceptionally good design and construction.

Eighth. Drilling and Boring. There has been much development in this class of work in recent years, two of the most important results having been the production of the radial drills and the multiple spindle drills. The former is much used for heavy work and that which is large and awkward to handle, as the drilling device, being movable to any desired point within a quite large radius, while the work remains in a fixed position, is capable of a very large range and various angles of operation. The multiple spindle drill is particularly adaptable to jig work where several different sized holes are to be drilled at one operation. A special design of this form of drill provides a special location of a spindle for each hole to be drilled in the same

direction in the piece, and all are drilled simultaneously, or in the time occupied in drilling one hole. Horizontal and vertical boring machines are used, not only for drilling large holes, but for boring out cylinders and other like castings requiring large and heavy boring work.

Ninth. Grinding. Great accuracy, efficiency, and economy have been realized in the use of grinding operations. This work may be divided into three classes: (*a*) cylindrical grinding; (*b*) surface grinding; and (*c*) disk grinding. In the first the piece is usually placed on centers, and revolves in the opposite direction to the grinding wheel. In the second the work, or the wheel, travels to and fro on a table similar to a planer table, while the wheel revolves above it and is gradually moved across it. Disk grinding is a kind of surface grinding, but is mainly used for the purpose of finishing or polishing the surface of machine parts having flat surfaces. In this form the grinding surfaces are composed of flat cast iron disks whose surfaces are cut with a shallow spiral line. The surface is covered with emery cloth cemented to it. The work to be ground is laid upon a table normally located at right angles to the face of the disk, but capable of being adjusted to any desired angle when angular surfaces are to be finished. Two of these disks arranged facing each other, and one of them made adjustable, are used for grinding opposite surfaces of flat pieces.

Improving the Design of Machines. The comparatively recent advent of "high-speed tool steel" and its ability to stand very high speeds, largely increased feeds, and heavy cuts, brought about conditions which called for much heavier and stronger machines. These the manufacturers at once began to design and build. But there remained many machines of the older, lighter, and less powerful types still in the shops. These were usually in good and serviceable condition, except as above stated. It therefore became an engineering problem to re-design, re-build, or strengthen these machines so as properly to fit them for the increased service demanded of them. The following is a simple example of how this work was accomplished.

In carrying out these improvements the process need not necessarily be an expensive one. The improvement should only be undertaken after a thorough examination of the machine and the work that is to be done upon it, by a competent and practical man, well versed in this particular class of work, and the expense of whose services will frequently be saved in the economy of the work of reconstruction.

A case in point is that of an eight-foot vertical boring mill of old design and construction, as shown in Fig. 209, which was required to do heavier and faster work than it was designed to do. The problem was to bring it up as near the capacity of a modern machine as possible. Upon examination it was found that the cross rail, saddle, and boring bar parts and the

supporting side posts were quite sufficient for a considerably increased duty. The driving mechanism, however, was weak and not sufficiently strong for heavy cuts or the fast feeds made possible by the use of high-speed tools. While the table support was not as rigid as could be wished for, it was decided not to spend any money on that feature, as the work it was to do did not require extreme accuracy.

The driving mechanism at A, Fig. 209, was constructed substantially like a back-geared lathe head attached to a suitable projection on the base of the machine, and whose main spindle reached to the edge of the circular table, and had fixed upon it a bevel pinion engaging a large bevel gear fixed

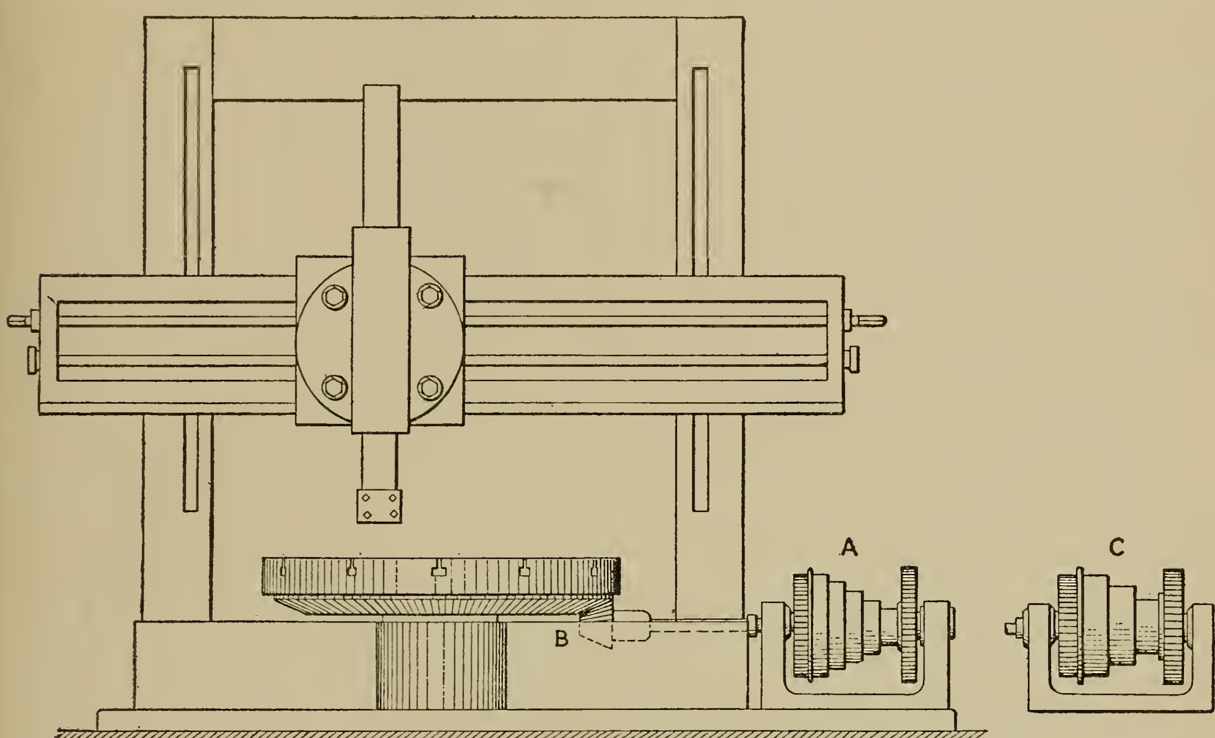


Fig. 209. — Increasing the Efficiency of a Vertical Boring Mill.

to the bottom of the revolving table, as shown at B. This mechanism consisted of face gears $2\frac{3}{4}$ inches, and the back gears $2\frac{1}{2}$-inch face, with a five-step cone of $3\frac{1}{4}$-inch face. In re-designing this feature the face gears were made $3\frac{1}{4}$-inch face and the back gears 3-inch face. The driving cone was made with three steps only, instead of five, thereby permitting the faces to be $5\frac{5}{8}$ inches wide, as shown at C. The driving bevel pinion at B was of proportionately large pitch, but was made of cast iron. To gain sufficient strength it was replaced by one of steel.

By this simple arrangement the power and cutting capacity of the machine was increased over 50 per cent, while the increase of speed was gained by changing one overhead pulley. Its working capacity could be still further increased by the addition of another tool holding head. Thus the first and second methods were realized in this machine.

Another method of increasing the efficiency of a machine by the addition of devices and attachments is more applicable when the work of the machine is a regular line of similar pieces. Special devices may be made for holding the work, so as to secure greater rigidity and to reduce the time required for putting in and taking out the piece of work.

Other devices may be made for better securing the cutting tools, or for using a greater number of them. For instance, in turning cone pulleys, the ordinary lathe tool block carries but one or, at most, two tools, while it is a comparatively simple and economical matter to construct a tool block carrying as many tools as there are steps to the cone, and turning all of them at once. A taper attachment will permit the pulley faces to be properly crowned. This suggests a wide field for interesting study and is well worth the best work that can be applied to it, and the devices that may be designed for almost any kind of product are numerous and valuable if carefully worked out by men who are well versed in this class of work.

Still another method, that of providing better tools, is a more simple question. If the tools are made of the ordinary grades of tool steel much greater efficiency can be realized by the use of high-speed steel. Its cost may be five or six times that of the ordinary tool steel, but this should not prevent its use, since it will be exceedingly economical in any event. The tool steel expense may be kept within reasonable limits by the use of tool holders for lathes, planers, and similar machines, as they will require only short pieces of small square steel as cutters, instead of the cutting portions being forged upon the end of a bar weighing many times as much. However, for heavy and rough work a solid tool is preferred by many good shop men on account of its great rigidity.

In the use of solid tools, the efficiency of the machine will be much affected by the form of the cutting portion of the tool. This will include not only the form given it by the tool forger, but the angles to which it is ground. To insure the proper treatment of the tool in this respect a good tool grinding machine should be used. This machine should be so constructed that tools may be rigidly held at the various angles required (which should be shown on an index), and uniformly and quickly ground.

This machine should be located in the tool room, and all tools requiring to be ground should be sent there and exchanged for like tools properly ground and held in stock ready for issue. This exchange should be made by errand boys, who should keep the operators supplied with sharp tools. Operators at the machines should not be allowed to grind tools except in rare cases and by order of the foreman.

The arrangement of machines with relation to each other and the transportation facilities necessary to serve them in an efficient manner is a problem

that is not often satisfactorily solved. Here again the particular nature of the product to be turned out must be taken into consideration and the requirements carefully considered and worked out in accordance therewith. The product might be large and heavy engine work, which would require a certain arrangement of machine in order efficiently and economically to carry the parts through the works. Or, it might be machines composed of many comparatively light and easily handled parts, which would necessitate quite a different array of machines and located upon an entirely different plan. Thus we see that the nature of the product will govern, not only the selection of proper machines, but the location of these machines in relation to each other. Necessarily this latter condition will decide the character and location of the transportation facilities necessary.

A specific example will be given from which general principles may be deduced that may be applied to other and quite dissimilar cases.

Fig. 210 shows the original arrangement of the machines in a department in a manufacturing concern, in which there was a large volume of heavy

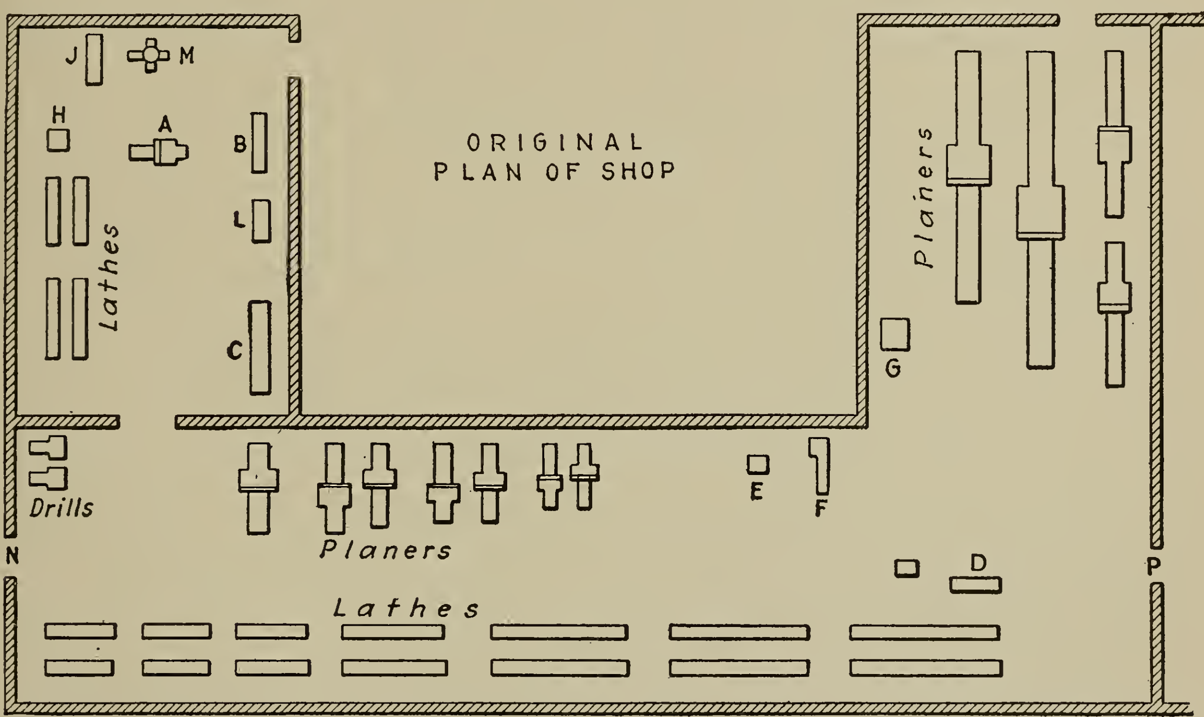


FIG. 210.—The Original Plan of a Shop Department.

planing. In the bay at the right of the plan was a group of large planers, while those of medium size were located at the rear of the main room, and a single small one at *A* in the bay at the left of the engraving. The main group of lathes were placed along the front of the main room, with a section of small ones along the outer or street wall as shown. There was a medium-sized lathe at *B*, and a heavy 68-inch swing lathe at *C*. Also a chucking lathe at *D*, near the right part of the engraving. In the main

room were two upright drills near the door *N*, and along the rear wall near the small planers a polishing head at *E*, a polishing belt at *F*, and an old-time suspension drill at *G*. Near the group of small lathes there was a sensitive drill at *H*, a slotter at *J*, a bolt cutter at *L*, and a horizontal hydraulic press at *M*. It will thus be seen that many of the machines were apparently located at random and with little regard for any definite plan as to their uses or the progress of the work.

In the operation of the shop, castings were received at *N*, the heavier ones put on trucks and taken to the group of large planers, many of them brought back to the upright drills, near the door *N*, some taken to the 68-inch lathe at *C*, and then back near the group of large planers to be erected. Forgings came in through the door at *P*, went to the planers in the main room, the lathes opposite them, or those in the left bay, then to the hydraulic press for force fits, then back to the erecting floor at the opposite end of the department.

Face plates were roughed off on the large planers, carried to 68-inch lathes at *C* to be turned, and, after a more or less wandering career, finally arrived at the erecting floor. Dirt and dust from the polishing head at *E* and the belt at *F* was quite injurious to the machines in the vicinity. Transportation facilities were crude and the continual moving of material and work in progress back and forth was not only expensive, but kept the main passage in the center of the room in a constant state of congestion and blockade much of the time.

The plan for re-arranging the shop is shown in Fig. 211, and was as follows: The group of large planers, those along the rear walls of the main room and the group of large lathes opposite to them were not disturbed. The other machines were moved to the locations shown. The left bay was practically cleared of machines and made an erecting floor, the lathe *B* being retained for convenience of small jobs during the erecting work. The group of lathes were eliminated altogether as they were no longer needed. A polishing room was built and the machines *E* and *F* placed in it, thus confining the dust and dirt nuisance in a small space. An overhead traveling crane was set up covering the entire space of this bay, giving great convenience for the erecting of machines. A small tool room was built and in it was placed a tool grinder *Q* and a twist drill grinder *R*. A door for the receipt of castings at *S*, and a floor scale were put in. Shop tracks were laid as shown running from the door *S*, across the scale and on to the group of large planers at the rear; also, through the center of the main room, from the doors *P* to *N*, with a turntable at the intersection of these tracks. Branch tracks run through the center of the erecting floor to the door *X*.

The planer *A*, formerly in the left bay, was added to the group of planers

at the back of the main floor, and beyond them the two upright drills were placed, and still further beyond the sensitive drill *H*. Beyond this were located the bolt cutter *L* and the chucking lathe *D*. A large radial drill was added at *T*, and a vertical boring mill at *U*. The old-time suspension drill at *G* was replaced by a modern "railroad" drill at *V*, that is, one over the shop track upon which was fitted a special truck for supporting heavy lathe beds to be drilled. An ordinary jib crane was set up at *W*, for the use of the planers.

By this arrangement most of the castings were received at the door *S*, weighed on the scale located there, and then moved on shop cars to the large

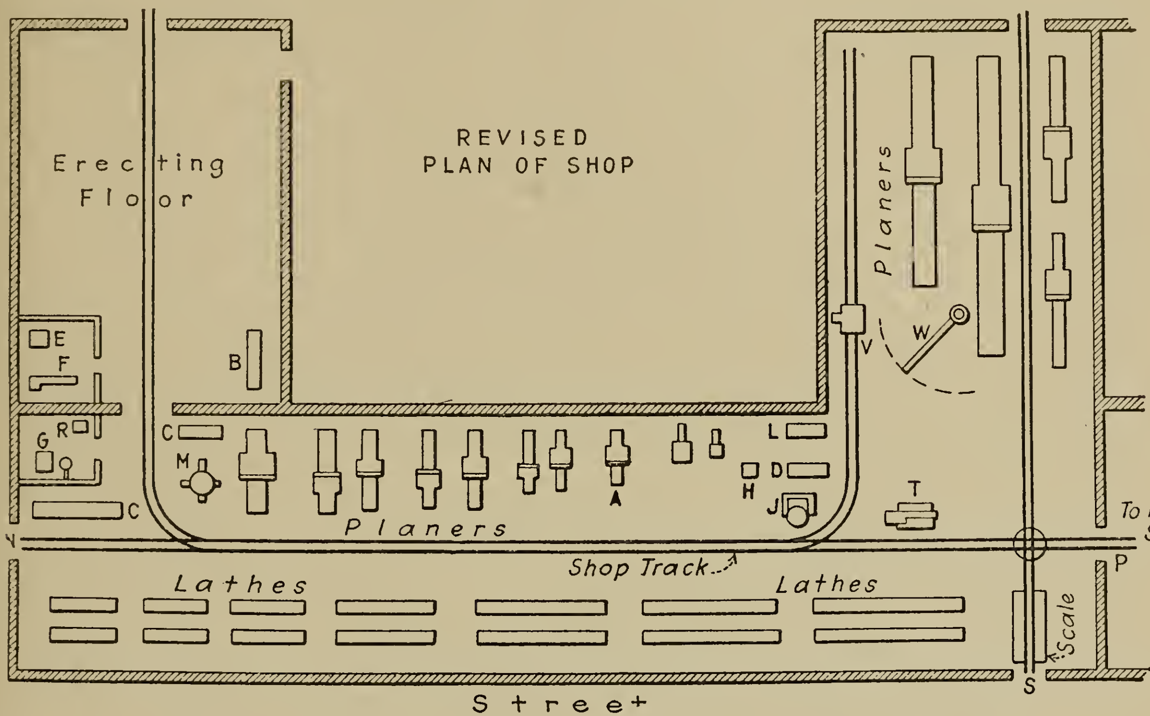


FIG. 211. — Plan of Department as Re-arranged for Greater Efficiency.

planers. Beds were scraped and afterwards drilled at *V*, and sent on shop cars to the erecting floor. Work requiring the use of the radial drill or the vertical boring mill was handled near the point of receiving castings and sent on in the same way. Face plates and spindles were finished on machines near each other and forwarded over the same line. Forgings were received through the door *P* and sent over the shop tracks to whatever machines were to perform the next operations upon them. Thus nearly all the work, particularly all the heavy work, was kept moving in the same direction toward the erecting floor, and the finished machines shipped out of the door at *X*.

By this arrangement there were no blockades, the cost of transporting materials was enormously reduced, and the output of the shop very considerably increased. An annual outlay of nearly $4000 for handling material was reduced to less than one-fourth of that amount and the work of the shop ran smoothly and satisfactorily.

The discarding of the six lathes paid for the vertical boring mill and the radial drill added, so that there was only the expense of the change from the old suspension drill to the railroad drill to add to equipment expenses, other than the shop tracks and cars and the two cranes, all of which were made in the shop. These were paid for out of the savings in transporting and shipping during the first twelve months and quite a balance left on the right side of the ledger.

Such results, or those of similar nature, can nearly always be achieved in very many of the older shops by systematic planning of machine operations, re-arranging the machines to suit a proper sequence of operations necessary for efficient and economical work, and providing proper transportation facilities. The subject so treated will tend greatly to increase the efficiency of the machines.

CHAPTER XXXIV

INCREASING THE EFFICIENCY OF MEN

Many methods for increasing the efficiency of men. Direct and indirect methods. Classification of methods. Special rewards. Personal instruction. Planning machine operations. Better machines, attachments, and tools. Better drawings. System of payments. Personal interest in the work. Agreeable shop conditions. The Bonus System. The Premium Plan. The Piece Work Plan. Requirements for a successful system. Causes of dissatisfaction. Shop operation sheets. Selection of Foremen.

There are many methods by which we may increase the efficiency of the men employed in the average manufacturing establishment. These will quite naturally fall into one of the two classes as follows, namely:

First. Methods directly affecting efficiency.

Second. Methods indirectly affecting efficiency.

Of methods which may properly be included in the first class, those tending directly to increase efficiency, we have:

(*a*) By giving him a special reward for performing an amount of good work over and above that which has been determined to be a fair day's work. This is commonly called "the bonus plan."

(*b*) By personal instruction as to the best methods by which the operative may handle his work.

(*c*) By planning machine operations and describing them clearly upon Shop Operation Sheets.

(*d*) By providing the operative with better machines, attachments, and tools.

(*e*) By providing better, clearer, and more easily understood drawings than those of former years.

Of matters and methods which operate indirectly to increase the workman's efficiency the more important will be:

(*a*) By adopting a system of payments that is agreeable to him as to methods and time intervals.

(*b*) By increasing his personal interest in his work.

(*c*) By making shop conditions more agreeable to him.

Referring to direct methods of increasing the efficiency of the workman, it may confidently be said that experience has amply proved that the greatest incentive to a workman is a special reward for unusual effort in turning out

his work. This work is sought to be accomplished by the Bonus System, the Premium Plan, and the Piece Work Plan, etc. Each of these has its essential principle, intended more or less to interest the workman as well as to benefit the concern.

The work for daily wages, without regard to the kind of work or the amount of the output, is usually monotonous and unsatisfactory to a man ambitious to better his condition. He may endeavor, by demonstrating his ability and energy, to attract the attention of his superiors and so lead to an increase in his pay. In this he is often disappointed, and all the more when he thinks he sees another man getting more pay for less effort and ability. The result is liable to be discouragement and a lessening of the output.

The Piece Work Plan is intended to remedy some of these difficulties. Sometimes it has done so, but frequently it has only served to aggravate them, depending to a considerable extent upon how it was managed. The results sought by this plan were:

First. To reduce the actual cost of the work to the employer.

Second. To insure a fixed cost which might be used as a basis in calculating total labor costs.

Third. To lower the amount and therefore the unit cost of supervision of the work by providing an incentive to the workman to use greater interest and energy in performing it.

Fourth. To increase the output of the plant.

Generally speaking, the question of the financial interest of the workman has seemed to receive rather slight consideration. The principal thought of the employer has appeared to be, at least from the workman's point of view, that of reducing the cost per piece to a less figure than it had been by the day pay plan, and to assure himself of a fixed price.

The plan is to have all mechanical work done "by the piece," whether it was a single operation by hand or machine, the entire work of making a single piece, or the making and assembling of a group of parts. As in day work the employer furnished everything but labor, although occasionally the workman furnished such small consumable tools as files, etc. The promise held out to the workman was that by a little extra effort he would be enabled to add considerably to his wages.

The success of the piece work plan depended almost entirely upon the accuracy with which the piece work rate was determined, and, secondly, on how well the rate fixed was adhered to, when the workman's wages were increased beyond what the employer thought was reasonable. The usual methods were crude and inefficient in comparison with those now in use. Generally the rate was based upon the ordinary output of a day's work on the day rate plan, and therefore computed by the interested workman him-

self. "Working for a rate" became the usual comment on a slow man. The result was that piece work rates were usually set much too high at the outset. This angered the employer, who retaliated by cutting the rate, generally to a lower point than it should have been. Then the workman would object and threaten to quit. Perhaps the next man "working for a rate" would do a fairer day's work, and the employer, remembering his former experience, would set the rate so low that even a good man could not make day pay at it. The difficulty might be patched up, but the situation was very likely to become an armed truce in which each party watched the other suspiciously. Friendly relations between the employer and the workmen were destroyed and the piece work plan was discredited by both.

The causes which were contributing factors to this condition appear to be as follows:

First. An improper system, or lack of system, for fixing piece work rates.

Second. The desire of the employer to make the rate as low as possible, or at least so that the workman should be able to earn little more than day pay, yet to turn out considerably more work.

Third. The desire of the workman so to manipulate conditions as to get as high a rate as possible notwithstanding his past experience that "a cut" would follow. All this is wrong in theory and worse in practice. The ethics of good business teaches us that no plan of adjusting the differences between the employer and the workman will long endure and give satisfaction that does not equitably provide for the mutual financial benefit of both parties without encroaching upon the rights of either. This is no visionary theory, but rather a condition that may be realized if proper methods are pursued and modern systems made use of. The importance of the question demands the greatest care and consideration in its solution. Like the development of all valuable methods and systems, it will cost something, although it should not be expensive as compared with the benefits that will accrue from it.

There are three methods for accurately determining equitably the piece work rate for the workman. The first method is that described of using the output of a workman on a day rate basis.

The second plan is to have the work done, not by the men who are afterward to do the work at the piece work rate determined, but by two different reliable and skilled mechanics, and then to average the results. This makes a much fairer, but usually a rather close rate when the work is done by the average operator.

The third plan is to carefully calculate the time of every movement in the various operations and to simplify them until every unnecessary waste

of time is carefully eliminated. This is called a "Time Study," and its final determinations are then incorporated in a "Shop Operation Sheet," which is used as a guide by the mechanic who does the work. This is really an equitable plan and perfectly fair for both sides, and both the employer and the workman must admit it to be the only scientific plan yet devised for such work.

By the use of the second plan the tendency is to attract to each class of work the men best fitted for the job. A good man will increase his output from 30 to 50 per cent, when working with the same machine and tools that he would use in day work. He will also perfect his methods and probably improve his tools somewhat, if he is assured against a cut in the rate, if by his ingenuity, ability, and energy he exceeds the expectations of the official who fixes the rate. He should be permitted to increase his output 50 per cent if he can do so and still produce good work.

It may seem easy to avoid the dissatisfaction over cutting rates by first setting a rate low and then raising it gradually until the proper point is reached, since workmen never object to the rate being raised. There are, however, valid objections to this method. Days and sometimes weeks will be spent in acquiring the data for these adjustments on a single piece, and the larger the number of different pieces handled the greater will be the time required and expense incurred. Other considerations will also enter into the matter. For instance, the overhead or general expenses, and the hourly rates upon machines, both of which will be seriously affected by the fluctuations of the output of the machines. The fact should not be lost sight of that any plan which tends to increase the output of machines, even while increasing the pay roll considerably, is usually more than counterbalanced by the lowering of the overhead expenses as considered pro rata with the value of the product.

The matter of accurately and intelligently fixing the price or a fair rate of machine operations is entirely practicable. Let us assume that we have a lot of cast iron chuck plates to finish in an ordinary engine lathe. This is taken as an example of an easy and simple job for illustration. In Fig. 212 is shown the sixteen different operations, and for purposes of analysis the chucking and mounting; in fact, each step up to the final removing of the piece from the lathe. To obtain a proper rate for this work it will be put in the hands of a fairly good workman and the time occupied in performing each operation will be noted by a time-study man, who observes the work, watch in hand, and notes the elapsed time. Being expert at this duty he will know if there is any unnecessary loss of time, and if he is not satisfied with the progress of the work, he will require the set of operations to be performed a second time. This will give a fair and accurate account of the elapsed time,

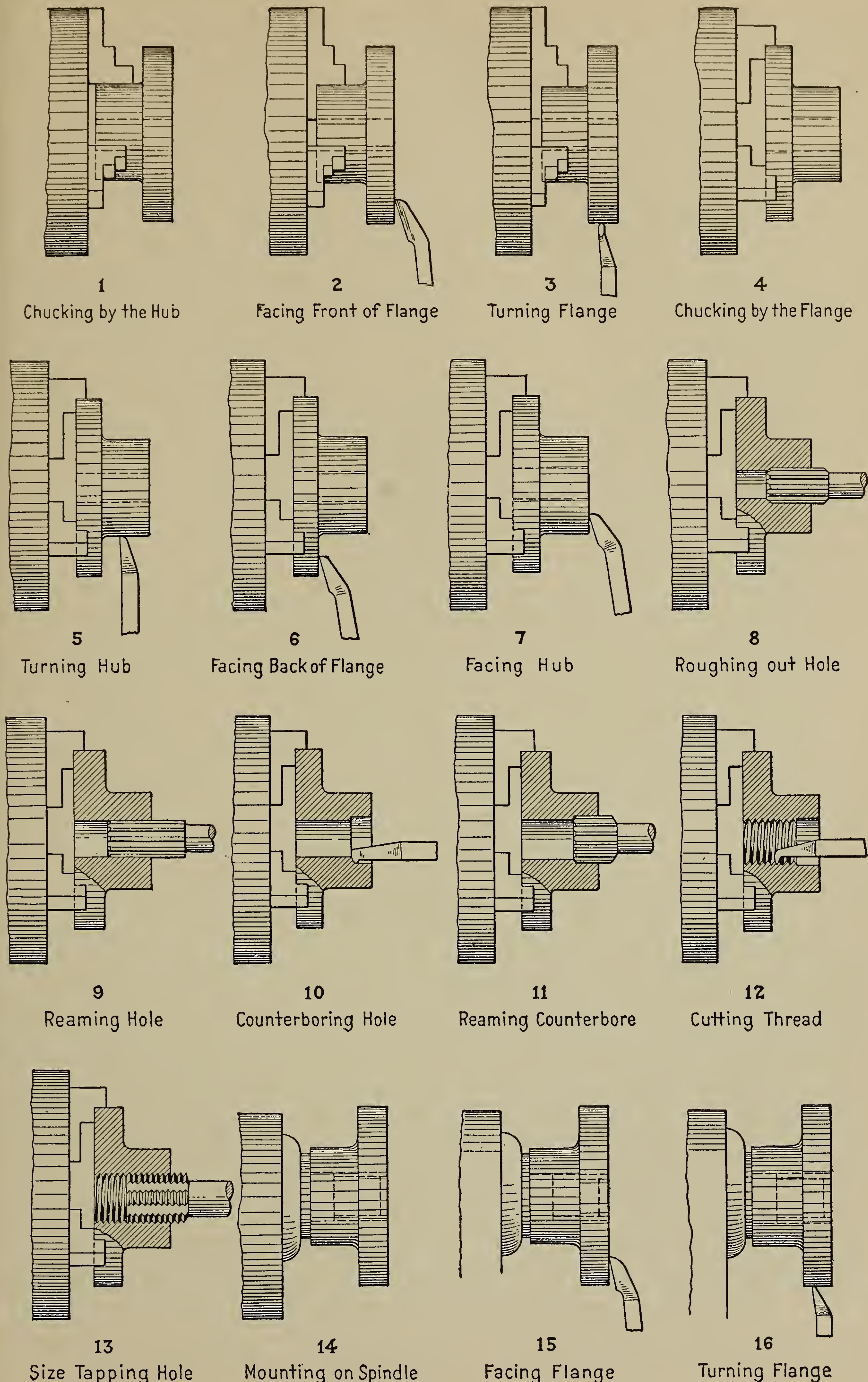


FIG. 212.— Consecutive Operations in Machining a Chuck Plate.

which may be safely used in calculating the piece work rate. These conclusions may be checked by having the operations performed by a second man and the time averaged as between the two.

Many of these operations can be calculated without the work being actually performed. For instance: turning cast iron, using tools of high-speed or self-hardening steel, may be done at a speed of 50 to 60 feet per minute, and a feed, on a roughing cut of 8 or 10 revolutions per inch, and on a finishing cut 15 to 25 per inch. In Fig. 212 roughing and finishing cuts are not shown separately, but it is to be understood that both are included, and that sometimes three cuts may be necessary, namely, roughing, sizing, and finishing.

As usually arranged, the results of a time study consisting of a series of operations is recorded upon a card of the form shown in Fig. 213. In this

No.		TIME STUDY CARD				Date
Part No.		Part Name				Machine
Man No.		Man Name				Dept.
Machine No.		Machine Name				Dept.
Op. No.	TIME					SUMMARY
	Set up	Set Tools	Cut	Remove	Total	
1						Total Time
2						Man Rate
3						Man Subcharge
4						Machine Rate
5						
6						
7						
8						Total Cost
Time Study Made By				Approved By		

FIG. 213.— The Time Study Card.

case the several parts of the operation are given for purposes of analysis. Thus we have the serial number of the operation, the time required to set up the job, to set the tools, to make the cuts, to remove the piece, and then to give the total time. These times are given in minutes and fractions, either seconds or quarter-minute periods. The best practice is in minutes and seconds, since some of the periods will be very short, and, if accurate calculations are required, quarter minutes are not sufficiently close.

When the proper time has been arrived at the operator is given the work together with the Piece Work Card shown in Fig. 214, which has the upper third portion completely filled out with the information required. At the center of the card is specified the quantity and description of the operation and the rate, and below is given the Standard Time, as "5 hours and 10 minutes per 100 pieces," or "time per piece 3.1 minutes" or "3 minutes

and 6 seconds each." The actual time is similarly filled in below when the work is finished, and the amount earned is entered on the central portion of the card. The card having been signed by the inspector after he has inspected the work, and approved by the foreman, becomes the authority for payment.

This method may seem unnecessarily intricate and exact, but if we consider the importance of a system that shall inaugurate and maintain a clear and fair understanding between the employer and his workmen on the subject of piece work, and the immense value there is in the system that will produce a good quality of work and a largely increased output, it will be found that the time and the money spent in organizing such a system and carrying

Order No.	PIECE WORK CARD	Date
Part No.	Part Name	Machine
Man No.	Man Name	Dept.
Machine No.	Machine Name	Dept.

Quantity	OPERATION		Rate	Amount	
	No.	Name			

Inspected By	Approved By

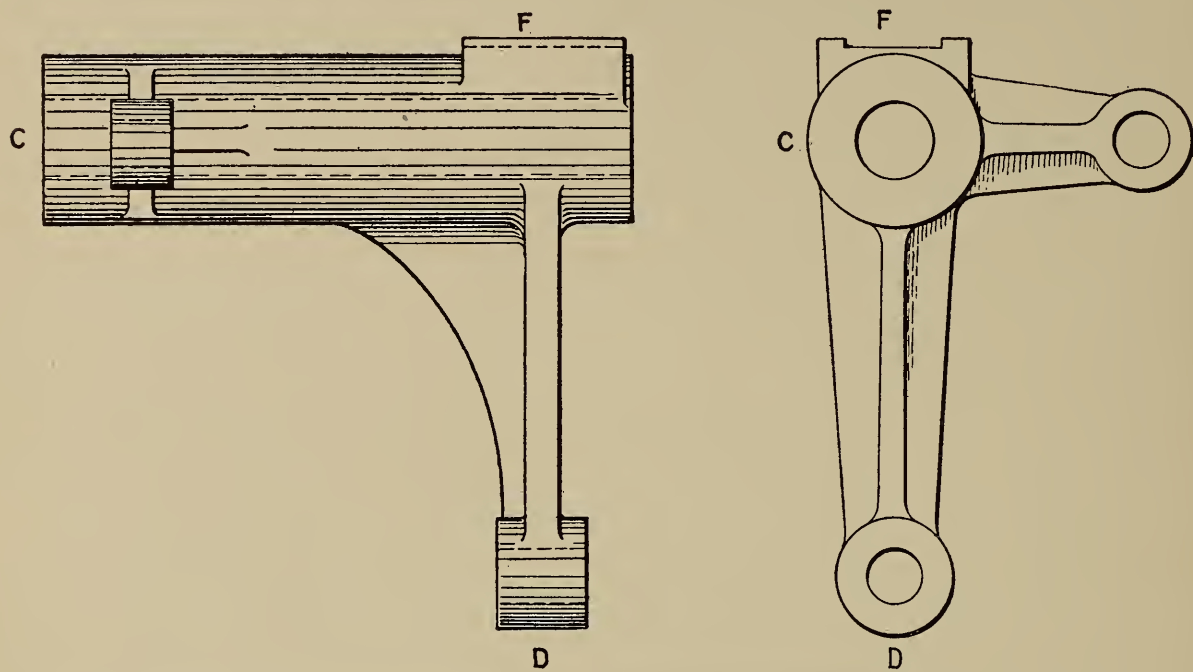
Fig. 214. — The Piece Work Card.

it on as a part of the regular routine of the establishment, will be the most economical and productive investment made in and about the plant.

The use of Shop Operation Sheets consists in providing sheets for the use of the workmen upon which is a drawing of the piece to be machined, a detailed description of each operation to be performed, and describing the tools, jigs, and fixtures to be used; the machine upon which the work is to be done; and giving the number of the drawing or blue print upon which the dimensions can be found. A sample form is shown in Fig. 215. These operation sheets are usually made from a printed blank on bond paper. The drawing is made by hand and the blank portions filled in on a typewriter, after which as many blue prints as may be necessary are made. The finished dimensions may be given on the drawing at the top, so as to avoid the necessity of referring to the sheet of detail drawings containing the piece to be machined.

It will be readily seen that these operation sheets are an important

factor in increasing the efficiency of the machine, although they are really intended for the better and more prompt instruction of the operator; and



PART BELL CRANK NO. B 35 MACHINE B				TYPE 14
Material *Cast Iron*		Date Compiled *Nov. 20, 1916.*		
OPERATION		TOOLS AND FIXTURES	MACHINE	DRAWING
NO.	NAME			
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

FIG. 215. — The Shop Operation Sheet.

having them at hand is of much assistance, not only in securing the proper sequence of operations, but in the rapidity with which the changes from one operation to another can be made. At the same time they give confidence and support to the operator in his work.

In the use of these sheets and the handling of all new tools, jigs, and fixtures the efficiency of the men will be greatly increased by the presence and advice of a trained and expert instructor, who spends considerable time in investigating and recording much detailed information which is exceedingly useful in handling the work economically and efficiently.

There are some other aids to increasing the efficiency of the workmen. Managing officials should endeavor to provide good, agreeable, and sanitary conditions among which may be mentioned: plenty of light, natural or artificial; shops comfortably warm in winter, and always well ventilated; good sanitary arrangements, ample and clean lavatories and individual lockers for the workmen; as high-grade associates or "shop mates" as the character of the work demands. The system of payments should be convenient. Most state laws require weekly payments. The practice of "holding over" two or three days' pay should not be in use. Special rewards or bonus payment for special effort should be promptly made, accompanying the weekly payment, if possible, and certainly not deferred for more than a week.

The selection of a class of foremen who understand human nature and have the ability to study men as well as conditions and adapt their methods of discipline to the personal characteristics of the men, so as to hold their esteem and respect and increase their personal interest in the work they do from day to day. To be really leaders and not drivers of the working force. Experience shows that all these matters make for success in shop administration and should be carefully studied and made use of as occasion may require.

CHAPTER XXXV

THE RELATION OF THE OVERHEAD BURDEN TO THE FLAT COST

The overhead burden. Complex problems. Operating expenses. Classification of accounts. A "going concern." Fixed charges. The expense burden. The supplemental burden. Apportioning the overhead burden to the flat cost. Labor cost. Material cost. Administrative expenses. Selling expenses. Profit. Component factors. The hourly plan. Its defects. The percentage plan. Its fallacies. A comprehensive view. Productive and non-productive labor. Cost of power. Machine rate. Man rate. Floor rate. Idle machines. Good effects.

That bugbear of all accountants "the overhead burden" is one of the most potent factors in the problem of cost accounting and one which requires the most careful consideration and expert analysis. Still the problems of cost accounting in manufacturing operations are many and various. Often those which at first appear to be simple and readily solved prove to be exceedingly perplexing and difficult to satisfactorily handle.

Probably the one point upon which there is the greatest amount of disagreement and perplexing argument is that of the proper handling of the overhead burden or overhead charges, or, as variously called, the "fixed charges," "the expense burden," or the "expense account," and of the proportioning or prorating it by some equitable method over the product turned out by the plant, so that each job or each order shall bear its fair share of the burden of the general expense of the manufacturing departments of the concern.

Realizing the immense importance and the far-reaching results of a proper and accurate handling of this matter of overhead burden in the routine of manufacturing operations, and the possibility of great losses due to carelessness, or a lack of appreciation of the importance of the subject, manufacturing experts, factory managers, engineers, and accountants have devoted much time to the investigation and study of the problems growing out of the conditions which practical experience has evolved.

Those problems which at one time seemed to the expert in accounting to offer trifling obstacles to their ready and accurate solution, have been conscientiously studied from various points of view and under a great variety of circumstances and conditions, their real value and importance understood, and deductions have been made for their proper solution. But new condi-

tions and new facts continually confront the engineer and the accountant at each succeeding investigation of the manufacturing operations of a new plant, until the field for profitable examination and study seems to be almost limitless.

It is a generally recognized fact that each manufacturing plant is unique in itself and always possesses some features distinctly different from any of those hitherto examined and which must be handled in accordance with these local conditions. Among all the problems in this complex question, that which concerns the proper and equitable distribution of the overhead burden of a manufacturing plant will be found to be beset with more varying conditions and be subject to more diversified opinions than all others which relate to the question of shop and factory accounting.

In this consideration of the question of apportioning the overhead burden to the flat cost we shall eliminate entirely the question of administrative expenses of the general office and also the cost of advertising and selling the product, limiting the detailed consideration to the manufacturing departments of the plant, and an examination of their expenses for productive and non-productive labor, fixed and varying overhead charges, and the cost of material.

With any sort of a common-sense system of bookkeeping it is not a particularly difficult matter to ascertain the total amount paid out for the general expenses of the concern, since these will include all operating expenses except those for productive labor and material. But just here enters one of those questions that frequently give trouble in the solution of these problems, and usually when least expected.

What are operating expenses? Clearly, those expenses demanded by the daily routine of manufacturing operations. True. But in the regular work of operating the plant there must be purchased, or made, tools for hand use, tools to be used in the machines, attachments to be used on the machines, and even new machines, and all of which are necessary for the economical machining of the product. What portion of these shall be charged to general expense? Naturally a part of these expenses will be charged to equipment. Here accountants, particularly those who have been used to the older methods, will disagree. Jigs and fixtures are required, for which drawings and patterns, as well as the fixtures themselves, must be made. Shall these be charged to the expense account, or shall the entire cost of making these accessories go into the equipment account along with the machines which they help to render economically operative?

A prominent author in discussing this matter has said that all drawings, patterns, tools, jigs, and fixtures should be charged to the expense account because "to the purely commercial mind, taking nothing on chances, the

forced value must appear to be the only proper value to be given to the factory plant in the accounts." Further the same author concludes that, "in the case of a forced sale, drawings, patterns, and special factory tools are found to be absolutely without buyers. To the mechanical mind it seems preposterous to write all costs of these highly prized shop treasures directly into the expense account."

In this connection it should be said that to the practical business man endowed with mechanical as well as commercial ideas the "going concern" with all its machines and tools, regular and special, in use at their highest efficiency, is his aim and ambition, and he is very likely to reckon on that basis, rather than to have ever before his mental vision the shadow of the auctioneer and the sheriff.

It is certain that men will make mistakes in judgment of business conditions and that losses will ensue. But not more in manufacturing enterprises than in any other line of business. The stock broker, for instance, conducts a business with much more liability to loss through depreciation, as well as from other conditions, but his accountant does not enter securities at their forced sale value.

Therefore it seems fair to consider the manufacturing plant in the light of a live, going concern, with the usual prospects for good business. Its operations are directed by a man who possesses a natural ability for judging commercial opportunities and business conditions, and at least a fair amount of appreciation of the value and excellence of good original designing as well as of the fact that the development and evolution of mechanical operations require the adoption of improvements from time to time in order to keep pace with legitimate competition.

Adopting this view we find that the overhead charges will consist of three factors, which may be summed up as follows:

Fixed Charges, covering interest upon the cost of the land, buildings, fixtures, power, lighting, heating, and transportation plants; insurance, taxes, water rates, etc.; the cost of maintenance and the depreciation of valuation.

The Expense Burden, including the cost of so-called non-productive labor, cost of lighting, heating, ventilating, cleaning, transporting material, the interest upon the cost and installation, and the depreciation charge upon machines.

The Supplemental Burden will be the cost of the temporarily idle machines, which, with the exception of the cost of power, cost as much as when working at full efficiency upon useful product.

The Overhead Burden will be the sum of the above three accounts, although the method of bringing them into the burden account varies with their individual characteristics.

Our problem is the proper apportioning of these charges to the Flat Cost of the product. What is the flat cost of the product? We may analyze the various factors and classify them as factors in manufacturing costs, in the following manner, without going back to the elementary accounts by which these factors are determined. The different classes of accounts or costs with which we have to deal will be:

Labor Cost. The amounts paid for productive or direct labor, that is, labor applied directly to the product, whether for operations on a machine or by hand.

Material Cost. The expense of all material that goes directly into the product and becomes a part of it.

Overhead Burden, which is composed as above explained. There will also be the following accounts taken incidentally into the progressive arrangement that follows.

Administrative Expenses. This will include the expenses of the general office, including salaries, interest, insurance, and maintenance of real estate, office fixtures, etc., and the cost of office supplies, including telegraph, telephone, express, postage, legal, traveling, and similar expenses; but not including any of these items in the sales department.

Selling Expenses. The same list of expenses as are given for the general office, to which are added the expenses for advertising, commissions, allowances, discounts and similar expenses incidental to marketing the product.

The Profit is such a percentage of the manufacturing cost as the management may determine and the state of the market may permit.

The Component Factors. To apply these factors in their relative and progressive relations we will have:

1. The Flat Cost consists of:
    - The Labor Cost,
    - The Material Cost.
2. The Factory Cost consists of:
    - The Flat Cost,
    - The Overhead Burden.
3. The Manufacturing Cost consists of:
    - The Factory Cost,
    - The Administrative Expense.
4. The Market Price consists of:
    - The Manufacturing Cost,
    - The Selling Expenses,
    - The Profit.

For ascertaining the proper relation between the flat cost and the overhead burden a number of well considered and practical plans have been

proposed, all of them having some merits deserving careful consideration. The two principally used, with some variations to suit local and individual conditions, have been as follows:

First. The Hourly Plan. By this method there is charged to each job or order a percentage of the total amount of overhead burden in proportion to the number of hours of direct or productive labor. This is found by dividing the total overhead burden by the total number of hours of productive labor worked for a given period, say three or six months, or a year, thus obtaining an hourly rate which may be added to each hour of productive labor on the job or order, in addition to the cost of material, to ascertain the flat cost of the job.

The plan is defective for the following reasons. It places all classes of labor, whether skilled or unskilled, and whether working with a few hand tools or with an expensive machine, on a level. By this method a job done largely on machines would not bear its fair share, while a job done by hand at the bench would be assessed with an amount far in excess of its proper burden.

Again, if two men receive the same wages, one of them operating a small lathe and the other a large planer, the burden charged for an hour's work would be the same for the small lathe as it would be for the large and expensive planer. In actual practice this problem will appear in this manner. Consider a job done on the small lathe

Machine rate	15 cents per hour.
Wages of man	40 cents per hour.
Total	55 cents per hour or,

on a basis of 8 hours per day, $28.80.

In the case of the job done on the large planer:

Machine rate.	45 cents per hour.
Man rate.	40 cents per hour.
Total	85 cents per hour, or

on a basis of 8 hours per day, $40.80.

By the above "hourly plan," or averaging plan, each job would be charged on a basis of $19.20; one job would be charged $6. more than is equitable, while the other would be charged with $6. less than it should pay. The defects of the plan are thus glaringly apparent. Of course not all jobs will show as great a discrepancy as these, but the fallacy is only one of degree, and the principle will remain the same in all cases.

Thus we see that this averaging process of dividing the burden must necessarily result in an overcharge on small work and an under charge on large work. To work with any reasonable degree of accuracy and equity it

would require that the employees be on a near equality as to wages and the work done on machines of nearly equal cost, occupying the same area of floor space and absorbing an equal amount of power. These conditions will seldom be encountered over an entire factory and never in a machine shop.

Second. The Percentage Plan. This plan assesses the overhead burden on a basis of the cost of direct, or productive labor on each job or order. In this case the total overhead burden is divided by the total amount paid for direct labor for a given period, as previously explained, and, using this quotient as a percentage of burdens, it is to be added to the cost of direct or productive labor and material on each job.

One of the fallacies of this plan is that it takes no account of the very important factor of time. For instance, if a low-priced man occupies twice the time in doing a job on a certain machine, as a man getting double the pay (which is by no means an unusual case), it naturally follows that while the cost of direct labor has been the same, the cheap man has occupied the machine twice as long, and yet the overhead charge has been the same.

The actual result with a properly fixed machine rate, as in the last case, will be as follows:

In the case of the low-priced man:

Machine rate, 2 hours at 30 cents	60 cents.
Wages of man, 2 hours at 25 cents	50 cents.
Total	$1.10

In the case of the high-priced man:

Machine rate, 1 hour	30 cents.
Wages of man, 1 hour	50 cents.
Total	80 cents.

By this it will be seen that the job will actually cost $37\frac{1}{2}$ per cent more when done by the low-priced man than if done by the high-priced man, which is in line with the usual experience of machine shop work requiring more or less skill. If the percentage plan is used, the cost would be the same, but there would be this very important difference in this practical question. The output per day or week would be reduced 50 per cent, which is a very important phase of the matter, and to recover this 50 per cent under the low-priced man condition we must double the machine equipment.

Therefore the plan of accounting is manifestly wrong, and might easily make a great deal of difference in the correctness of the resulting accounts, particularly in a shop where there is a great diversity in the cost of the machines in use. In fact, it might render the method useless, so far as giving accurate, or even uniform, results is concerned.

A competent authority thus comments on these two plans. "The most unsatisfactory feature of both plans is that they make no provision for charging against a piece of work the interest and depreciation belonging to the machine on which the work is done. Both plans add the gross interest and depreciation to the other items of shop expense and then charge the total amount against the work on a flat rate or average basis which ignores the individual machines. On small and medium sized machines the interest and depreciation item is of small importance, but on the large ones it is the most important of any, and, indeed, on very large ones more important than all the others added together."

While the time or hourly plan corrects some of the defects of the plan of percentage of burden to the cost of labor plan, it brings in quite as erroneous ones of its own. It takes no cognizance of the value of the machines used, whether they cost a hundred dollars or several thousands, and a speed lathe might be assessed with just as much burden as a 72-inch planer.

Again, a boy earning seven dollars a week would count for as much as a machinist getting four dollars per day, so far as overhead charges are concerned. This plan would work many glaring errors, particularly in a manufactory having a large variety of machines, and where the work ranges from comparatively small to quite large and heavy parts. In a manufactory in which the work is quite uniform and the machines upon which it is done are nearly of the same first cost, and where the wages of the operatives do not vary to any considerable extent, either of the above plans may answer all reasonable requirements.

However, if we carefully consider the questions, we shall be forced to the conclusions that where these conditions do not prevail we must look for some more comprehensive plan that, while necessarily more intricate and difficult to administer, will give with a reasonable degree of accuracy the actual costs of products, and enable us to know in what department profits and losses occur, and what product, department, or individuals are responsible for the one condition or the other.

To do this we must take a comprehensive view of the questions involved and not content ourselves with the idea that all the factors in the case are considered at their proper value when we say that "we have labor, so much; material, so much; and general expenses, so much; and the sum of these is the total cost." As to total amounts this may be perfectly correct, but it is detailed information that we want. We know that the total is so much, but why is it such a large amount? To answer this question we must analyze this expense and ascertain what are its component factors.

Neither can we consider in lump sum such expenses as interest, insurance, depreciation, and similar burdens, since some of these will enter into plant

accounts, some into equipment accounts, and some will be chargeable to the labor account. It is true that all expenses for interest, insurance, depreciation, etc., must eventually be borne as part of the cost of the product, but the time and the method of taking them into the account are matters to be carefully considered if we are to avail ourselves of the opportunities which this operation presents to record and make use of the valuable detailed information that may be derived from the procedure at this stage of accounting.

We must know the details of this matter, for what purpose the money was spent, and to what accounts it must be charged in order to obtain a control over these expenses which will be of value in our effort to reduce them to an economical basis. To obtain this detailed information we must go back to the origin of the various matters which occasioned the several items of expense.

We have men and machines. We must have buildings to house them and consequently land upon which to erect these buildings. These buildings must be lighted and heated. We must provide for the transportation of stock and materials. There must be an equipment for fire protection. These costs will all be subject to 5 per cent interest charge. Another 5 per cent for depreciation, and the cost of maintenance and fire insurance. Lighting and heating must be provided for in a similar manner, and subject to like charges, except insurance.

There will also be the wages of all non-productive employees, such as the shop superintendent and his office force, foremen, tool keepers, watchmen, sweepers, carpenters, engineers, firemen, inspectors, laborers, and all others who do not work directly on the product of the concern. The sum of all these items divided by the floor area in square feet will give us a factor called "floor rate," which we can use as one of the components in determining the rates for machines and men.

The cost of power will include the percentage on first cost of the equipment for that purpose and its installation; its depreciation; its maintenance and operating expense of labor, fuel, and supplies. From the horse power generated we obtain the cost of power per horse power hour. This is done by dividing the entire expense of generating power by the total horse power generated, say for a year, and dividing this by the working hours for a year, now assumed to be 2500.

We obtain an hourly rate for a machine by the use of the following factors, viz.: (*a*) 5 per cent interest and 5 per cent depreciation on its cost and the cost of its installation; (*b*) the cost of its maintenance; (*c*) the cost of insurance; (*d*) floor rate, calculated as the number of square feet actually occupied by it and the space necessary to handle the work to be done upon

it; and (*e*) the cost of power, ascertaining the power required and using the cost per horse power hour.

In assessing the value of machines for the purpose of obtaining a machine rate, it is not necessary to assess them separately at their actual cost. The results may be obtained with sufficient accuracy by dividing them into classes, commencing with class A, including all machines costing less than $500; class B, those costing from $500 to $1000; class C, $1000 to $1500; and so on. This method will not affect adversely the value of the results.

The man rate we obtain by (*a*) assessing pro rata to the men all the floor space not occupied by or assigned to the machines. While this varies widely in different shops, it is an important matter for two reasons. First, it costs as much, with the exception of the charge for power and repairs for an idle machine as for one working at its full capacity. Second, the idle machines are usually the larger and higher priced machines, and therefore the most necessary to look out for on the score of economy.

Each machine should be numbered in large, plain figures in some conspicuous place. The cost clerk should have a book in which he records the number, machine rate, and a record of its idle and running time. The latter record he will obtain from the time cards, which should always give the machine number as well as the man number on every job done upon a machine. The idle machine record will be made up once a month, and the sum of the hourly rate of all idle machines during the month prorated over the entire number of machines, increasing their rates by the amounts thus ascertained for the following month.

In cases where the fluctuations in this account are slight, longer periods may be used, say three or six months. However, the prime object of this account is not so much to ascertain and account for the exact amount of the machine rate to the fraction of a cent per hour, although that is valuable so as to keep the record of idle machines for administrative purposes and as an indication of machine efficiency and shop discipline, in which capacity the information derived is of much use to the superintendent and factory manager.

By this method we shall frequently ascertain that there are machines in the shops that are adapted to some special work only, and that are idle for such a large portion of the time that they are extremely unprofitable, or that entail such a positive loss that they should be sold, or replaced by other machines better adapted for the work.

To carry this idea a little further and to effect still greater good results, the record of machines should be separated into an account for each department. This will bring the matter home to the head of the department. It will exhibit the relative machine efficiency of the different departments. If

we can show a foreman that his machine rates, and hence his costs, are being materially increased by several machines being habitually idle, he will either get busy in finding profitable work for the machines or getting rid of them altogether.

Frequently a machine that is idle much of the time in one department may be transferred to another department where it may be profitably employed. This fact, being demonstrated, will be of value in bringing the foremen together in discussing these matters and the foreman who has more work of a certain kind than he has machines to do it with will be alert to find another foreman who has such a machine and not enough work to keep it occupied. An exchange will be effected that will be a saving in idle machine rates to one department and an increase in the machine capacity of the other, and consequently a matter of considerable value to the plant in a general way.

Usually such good results will be automatically brought about without the intervention of the superintendent or controlling authority. There will be the continual tendency to keep the foreman alert to a higher plane of machine efficiency for the entire plant.

CHAPTER XXXVI

MANUFACTURING COST SYSTEMS

The so-called cost system. Bookkeepers and shop men. A growth but not a system. Requirements of an efficient cost system. Analysis of requirements. Relation between the cost system and the shop management. What is an accurate accounting for manufacturing operations? Real estate. Power Lighting. Heating. Shop transportation. Tools and fixtures. Materials. Non-productive labor. General office. Machine rate. Man rate. Productive labor. Sales department. The various forms of orders. Progress of orders. Drawing material. Inaugurating a cost system. Careful examination of conditions and accurate analysis necessary to success.

There should be no argument as to the necessity of a well formulated and accurate system for ascertaining the actual costs of the product, including every item of expenditure that may have been incurred directly in turning it out, completely finished and ready for shipment.

Yet if we examine the so-called cost systems in many manufacturing establishments of the present day, we shall find that what is by courtesy called a cost system has grown out of the old-time methods of commercial bookkeeping, to which has been added from time to time a plan, a card, or blank, for this detail or that; the method having been arranged sometimes by one man and sometimes by another, with no general plan to guide and direct these detail matters. Thus, if a detail is a matter of shop work, a shop man is likely to arrange it from a shop man's point of view without much regard to its effect upon the commercial accounts or the office methods of the concern.

In a similar manner, if the matter should come to the attention of the manager, he is likely to set a bookkeeper to devise a plan, and he, being prone to view the matter from the bookkeeper's position without regard to the shop condition which may effect, or which may be effected by it, will arrange some plan entirely at variance with good shop practice.

Therefore, the work of attempted cost accounting becomes a thing of shreds and patches, a growth, but not a system in any proper sense of the word. Much of the work is duplicated, and there is very liable to be a maximum of expense and a minimum of efficiency. The information gained under such circumstances and by such methods is of an uncertain character and of no great value in determining actual facts in relation to the conditions of the

business. The effect on the management and efficiency of the shop is rather to discourage honest effort toward better conditions than to be any incentive to increasing the output or raising its standard.

An efficient cost system should work to the advantage of both the shop and the office. In fact, it ought to have a beneficial effect upon the sales department as well, thus increasing the efficiency of the administrative, the manufacturing, and the selling of the product.

The requirements of a good cost system are quite definite and important in the management of a manufacturing enterprise as well as in the duty of accurately accounting for the cost of the work. The most prominent of these requirements are as follows:

First. To give, within a reasonable time after the work is completed, the actual and complete costs, including every item of expense to the ownership of the plant, of the operation of the plant as a whole; of the operations of each department of the plant; of the costs of each operation, and the cost of each machine part; of the cost of assembling the groups of related parts; of the cost of erecting the completed machine; of finishing, testing, and shipping it; and the cost of advertising, and selling, or marketing the product.

Second. It should tend to the closest economy in the purchase of all material, and in the care, issue, accounting for, and the use of it.

Third. It should secure the greatest economy of the wages paid for labor, not through lowering wages, but through increasing the efficiency of the workmen by accurately accounting for their work and providing for special remuneration for special individual effort and efficiency.

Fourth. To decrease the cost of all manufacturing operations through accurate records of past and present performances, and their logical analysis and comparison, by which improved methods may be formulated and the efficiency of men and machines secured.

Fifth. To increase the volume of output of the concern by means of the economies mentioned in the last paragraph, whereby the increase of efficiency, the shortening of the time necessary to do the work, and the decrease of costs have combined to largely increase the producing capacity of the plant.

Sixth. To increase the profits of the concern, by reason of the fact that costs of all parts of the work having been accurately determined, correct estimates may be given with confidence, and closer figures may be made upon proposed work than is possible with a rival firm not so accurately informed as to costs; whereby the concern stands upon a better basis in getting new business. Losses are also avoided, as an accurate knowledge of costs shows the manager what works to avoid as unprofitable.

The cost system must not only show a correct record of all manufacturing operations and all fluctuations of costs, but it must show why these fluctuations have occurred and fix the responsibility, first, upon the proper department, and, second, upon the official or individual who may be held responsible.

There is a close relation between the cost system, the shop methods, and the commercial accounts. It should be thoroughly understood that the cost system and the shop methods must not only work in harmony with each other, but, also, with the general accounting system of the concern, so that each may assist and support the other in attaining that success which comes from the union of effort on the part of all concerned.

While some of the results here enumerated are not, strictly speaking, within the province of the cost system, and belong more particularly to the work of shop management, these two branches of the work are so interwoven with each other that it is not practicable to discuss the one without including more or less of the other.

In inaugurating a cost system there are certain calculations to be made as to the fixed charges or expenses that are of the utmost importance, and without which it is impossible to formulate a complete or accurate system of cost accounting. It is not sufficient to say that there are commercial costs with which the manufacturing department have nothing to do, but which will be properly taken care of by the bookkeepers. It is not possible to obtain accurate costs of manufacturing operations, and properly distributed as commercial charges after the product is turned out.

Interest, taxes, insurance, and like charges are as properly a part of the cost of manufacturing as the wages of the workmen or the cost of material.

Machines vary greatly in first cost, hence there is much difference in interest charges. They also vary in a similar degree as to power to drive them and the cost to house them, hence in the real estate and similar charges properly assessed against their operation and output.

There are many other and equally good reasons why all these expenses should be taken into the accounts of manufacturing operations at the earliest possible moment.

By accurate accounting for manufacturing operations is not meant simply all the expenses of a department as compared with all the output of that department. Costs should be in detail and not only cover an order for a machine, but the cost of its several parts, and if a portion of a regular production order, we should have the costs of the different operations on the parts, and also the cost of assembling the groups of related parts and that of erection, finishing, and testing the machine or device. Therefore we must arrange the plan of the general accounts and work out the necessary calcula-

tions before entering upon the detailed work of the plan. The classification of accounts and the methods of using them will be as follows, namely:

First. Real Estate. (*a*) Interest, 5 per cent on the cost of the land and preparing it for the buildings, and on the cost of the buildings and the fire equipment for them; (*b*) Depreciation of real estate, unless the charge is balanced by the appreciated value of the land; (*c*) Maintenance and renewal of buildings; (*d*) Fire insurance and taxes.

The sum of these expenses for a year is divided by the number of square feet of floor surface of the entire plant. This gives a burden per square foot per year. It is reduced to an hourly rate by dividing it by 2500.

Second. Power. (*a*) Interest, 5 per cent on the cost of equipment for power generation and transmission, and its installation; (*b*) Depreciation, 5 per cent; (*c*) Maintenance and renewals; (*d*) Fire and boiler insurance; (*e*) Floor rate of boiler and engine rooms as ascertained in first paragraph; (*f*) Cost of fuel, water, and supplies; (*g*) Wages of engineer and fireman.

The sum of these expenses for a year divided by the horse power generated, and this amount by 2500, gives the cost per horse power hour.

Third. Lighting. (*a*) Interest, 5 per cent on equipment and its installation; (*b*) Depreciation, 6 per cent; (*c*) Maintenance and renewals; (*d*) Power, charged per horse power hour as in the second paragraph; (*e*) Supplies, wages of electrician, etc.

The sum of these expenses for a year divided by the number of lights, on the basis of incandescent lamps (allowing 10 incandescent lamps as equal to one arc lamp), and dividing this amount by the number of hours of lighting during the year, will give a cost of maintaining each light. With this factor the cost of lighting any and all departments is readily computed. As there will be considerable variation from month to month, this account should be made up monthly.

Fourth. Heating. (*a*) Interest, 5 per cent on the cost of equipment and its installation; (*b*) Depreciation, 6 per cent; (*c*) Maintenance and renewals; (*d*) Power, or its equivalent in steam, for heating; (*e*) Labor as may be necessary.

The sum of these expenses divided by the space to be heated (100 cubic feet being taken as a unit) gives the cost of heating, from which the expense of heating any room or department may be calculated. This account is to be made up monthly as it will fluctuate considerably from month to month.

Fifth. Shop Transportation. Shop tracks, cars, elevators, cranes, etc. (*a*) Interest, 5 per cent on equipment and its installation; (*b*) Depreciation, 5 per cent; (*c*) Maintenance and renewals; (*d*) Power to operate cranes, elevators, etc.; (*e*) Wages of operators.

This being a general account floor rate is not charged.

Sixth. Tools and Fixtures. (*a*) Attachments and fixtures made and used upon a certain machine are considered a part of that machine and added to its value; (*b*) Regular hand tools, as drills, reamers, taps, dies, etc., are a part of the shop equipment and the interest on their cost, plus the expense for maintenance and renewals should be added to the general expense; (*c*) Special tools necessary for work on a certain order are charged to that order. If the order finally becomes a regular line of work, then tools will be charged to the general expense as above.

Seventh. Materials. This includes all raw and manufactured materials and supplies, purchased parts, whether in the rough, partly or completely finished, which are applied directly to the product. It will require space to store this material, men to handle, issue, and account for it; these expenses become a part of the general expense account and are charged as overhead burden. The items will be: (*a*) Floor rate for space occupied for storage; (*b*) Interest, 5 per cent on the average amount invested in material; (*c*) Insurance on material; (*d*) Lighting and heating store room; (*e*) Labor, handling, and accounting for material.

Eighth. Non-productive Labor. (*a*) Wages of all employees not working directly upon the product. This includes superintendent, foremen, gang bosses, clerks, laborers, and others, except when on work properly chargeable to production orders.

Ninth. General Office. (*a*) Real estate charges as explained in the first paragraph; (*b*) Interest, 5 per cent on furniture and equipment; (*c*) Insurance, 5 per cent on same; (*d*) Maintenance and renewals of same; (*e*) Office supplies; (*f*) Lighting, as explained in third paragraph; (*g*) Heating, as explained in the fourth paragraph; (*h*) Legal, traveling, telegraph, telephone, postal, express, freight, and trucking expenses.

Tenth. Machine Rate. Made up for each machine. (*a*) Interest, 5 per cent on value and installation; (*b*) Depreciation, 5 to 10 per cent, according to the kind of machine, class of work, and hours used per week, month, or year; (*c*) Maintenance, renewals, and repairs; (*d*) Floor rate, including space occupied by the machine and the space necessary for handling its work; (*e*) Power for operating the machine. The sum of these expenses for a month or more is to be reduced to an hourly rate, as already explained.

Eleventh. Man rate. (*a*) Floor rate; (*b*) Consumable tools and supplies; (*c*) Liability insurance. The floor rate chargeable to each man is to be computed as follows: From the entire area of floor space or surface subtract the amount assigned to machines plus that occupied by the power plant. Divide the remainder by the number of productive men. This method will place the proper burden upon such departments as the assembling room, which contains few and often no machines. The amount so determined is reduced

to an hourly rate to be charged as a burden to all productive labor. This rate is assessed separately to the departments equipped with machines of varying numbers and sizes, or with no machines at all.

Twelfth. Productive Labor. (*a*) Wages of all employees working directly at hand or machine operations on the actual product or output of the plant. (*b*) Man rate as explained in the eleventh paragraph.

The Sales Department, while connected with the general office, is an entirely separate matter in relation to its accounts, in consequence of its work being that of marketing the product, and its expenses are entirely commercial expenses rather than manufacturing expenses. It must bear its proportion of the real estate charges of the general office building according to the space occupied by it, and its entire expenses are distributed as a percentage over the product after it is completed and ready for the market.

Actual manufacturing operations begin with ordering the work into the shops. In every well conducted manufactory there should be nothing commenced until definite, written orders, regularly issued by competent authority, have been received. These orders should specify exactly what is to be done, and generally give a time limit for completing the work. In cases where a lengthy description is necessary and cannot be written on the regular order blank, reference should be made to specifications or drawings, or both, attached to the order and forming a part of it. There should be nothing left indefinite or about which a doubt or question may arise in the future as to the precise nature of the work described. The importance of this point cannot be too strongly emphasized or overestimated. In cases of emergencies a new order may be issued, or an existing order changed or suspended by a subordinate official, who will report the fact to his immediate superior as soon as possible after such action, giving in writing the reasons for doing so.

Theoretically all orders are issued by the Manager or General Manager, as the case may be. If there is a General Manager in charge of the entire business, and a Factory Manager in charge of all manufacturing operations, both may issue such general orders as are appropriate to their positions. Thus the General Orders for the regular product of the plant may be issued by the General Manager, while the others for, (*a*) operation of the plant, (*b*) maintenance and renewals of equipment, and (*c*) maintenance and renewals of real estate will be issued by the Factory Manager.

The form of these orders is as follows: Fig. 216 shows the General Production Order, issued by the general manager for making a specified lot of machines for stock. In the line "machines, attachments, tools, fixtures," such words as are not required are to be erased by drawing a line through them. They are serially numbered and dated. When necessary a date may be given for their completion; or for the completion of certain parts, or groups

of parts, and the balance at a later date. The date "received in factory" will be the beginning of the time limit for completion, in case it has been given as "30 days," "3 months," etc. This order is to be made in duplicate, one copy of which is sent to the Factory Manager and one retained by the General Manager, or in triplicate, and one copy sent to the Engineering Department, so that the necessary drawings may be furnished.

STOCK PRODUCTION ORDER

No. ________ Date ________

Make for stock the following
MACHINES, ATTACHMENTS, TOOLS, FIXTURES.

Quantity	Description	Size

To be completed ________ Rec'd in Factory ________

Order completed

________ ________
GENERAL MANAGER

FIG. 216.—General Production Order Card.

Or, as is the better procedure, the order when received by the factory manager will be entered in his Order Book and sent to the Production Engineer, or similar official, in charge of the Planning Department, in which all orders for work, drawings, shop operation cards, etc., are issued. This official will issue the Sub-Production Order Card shown in Fig. 217. This order gives the general order number by which this particular work or operation will be identified. It may be issued for a large number of small parts, which are to be made and turned in to the Finished Parts Store Room, from which they may be drawn on requisitions for assembling of erecting; or it may be issued for the making of the number of parts required for the general production order whose number it bears. Several Sub-Production Orders may be issued for work in different departments on the number of the one general order. The blank lines to be filled in this order explain themselves. A similar form is used for assembling, erecting, testing, etc., except that different colors are used, and duplicates are filed in the office issuing them. But caution should always be used lest too many blanks are used and confusion result, as it is much better to make one card or paper blank do as many different things and perform as many different services as possible, even through different departments, each of which may add the

necessary endorsement and pass it along. When so used the blanks may need to be of larger dimensions and have appropriate spaces for the several endorsements of the departments through which they may pass.

Gen. Order No. ____	SUB PRODUCTION ORDER STOCK	Date ____	
Serial No. ____	Piece No. ____	Drwg. No. ____	To be completed ____
Quantity	Description		
Completed ____			

FIG. 217.— Sub-Production Order Card.

When a special machine, attachment, fixture, etc., is to be built the General Manager will issue a Special Production Order of the form shown in Fig. 218. This order is handled in a similar manner to the Stock Produc-

SPECIAL PRODUCTION ORDER No. ____	Date ____	
Make for ____	Address ____	
Their No. ____	Their Date ____	To be Shipped ____
Date Completed ____		____ GENERAL MANAGER

FIG. 218.— Special Production Order Card.

tion Order, Sub-Production Orders being issued to the various departments concerned. Usually specifications or drawings, or both, accompany it.

For such work as the operation of the plant, maintenance and renewal of equipment, maintenance and renewal of real estate, etc., orders under the

general name of "plant orders" are issued. They have written or printed upon them the particular work that each class covers, and should be of a distinctly different color from production orders. In numbering all general orders are in one series. This serial number is placed on all sub-production orders and a serial number for the particular class added. Or, the general serial number may be used with a symbol of one or more letters prefixed, as X for experimental work; R for repair work, etc. It is sometimes convenient and practical to prescribe limits for the use of serial numbers. For instance, general production orders may be numbered from 1 to 2000; plant orders from 2001 to 5000; and sub-production orders from 5000 up.

All orders, when the work called for by them has been completed, will be returned to the official issuing them unless there is a specific instruction to the contrary.

All material is "drawn from the store room," whether actually in that room or stored elsewhere, but accounted for as "in store." This will include castings and similar rough stock, as well as purchased parts and small materials; and from the finished parts store room the parts manufactured in the plant. Fig. 219 shows the form for a Requisition for Supplies Card.

REQUISITION FOR SUPPLIES

Req. No. ____________ Date ____________

For the ______________________________ Dept.

Store Keeper, please issue the following articles for use in this department.

Quan.	Dimensions	Description	Value	

To apply on Order No. ____________ ____________ Foreman

Issued ____________ Received the Above ____________

Fig. 219.— Requisition for Supplies Card.

It will cover all classes of material and supplies. For convenience these cards may be of different colors for the different departments. A carbon copy should be retained by the official signing them, and the original, with the store-keeper's report thereon, sent to the cost clerk. This report will give rates and values of the material issued.

In inaugurating a new cost system, it should be remembered that the first duty is to make a careful examination of the plant in general and of each of its departments, and the methods of manufacturing and cost ac-

counting, as well as of the general and subordinate offices and their existing systems. This examination should be made by an experienced and trained expert, who should make a careful study of all conditions so as to be able to formulate plans and so co-ordinate them as to produce the best results with the least cost and without undue friction between the managing officials and the departments, or between the different departments forming the plant. The importance of this examination, the carefulness with which it is made, the thorough and painstaking study of its conditions and elements, and the accurate deductions made therefrom will in a great measure determine the success of the cost system that is finally decided upon.

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